The AMSAT® Journal

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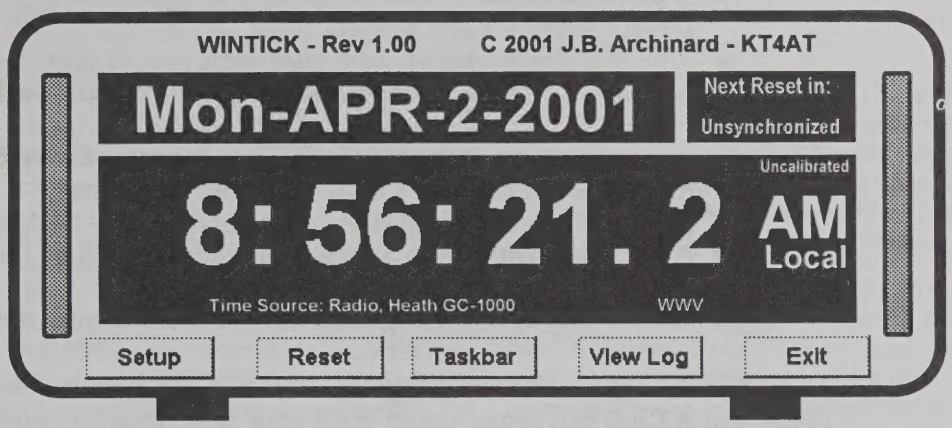

Figure 1. The WINTICK Clock.

Time Acquisition/Control Software Sets PC Clock to UTC

(and keeps it there for satellite tracking under Windows 95/98/NT2000/ME®)

J. B. "Arch" Archinard, KT4AT
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The subject matter of this article, time acquisition and maintenance, is not discussed very frequently. However, accurate satellite tracking requires a precise UTC time reference, especially for the bands above 1 GHz. It is even more critical if Doppler shifts are to be automatically canceled. The Windows operating system allows multiprocessing and multithreading (see Reference 1), which makes it possible to run a time-control software package in the background, on the taskbar, delivering a high quality time clock to the satellite tracking program. The WINTICK software discussed in this article supports

[continued on page 4]

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Status Review

Sometimes it is worthwhile to take an inventory of where we are, and where we think we are going. The last 12 months or so have been very productive for AMSAT, and we should consider some of our accomplishments. Acknowledging that there are some very differing views in AMSAT, I present these thoughts in order of accomplishment.

Firstly the International Space Station, the Russian Module, was launched and connected to the rest of the Space Station. Then followed by *Expedition One* providing limited but welcome Amateur Radio contacts. Shortly thereafter, Phase 3D was launched from Kourou, French Giuana in a near perfect trajectory and then promptly re-named as AO-40. Telemetry was received within hours albeit on two meters in place of the planned 70 cms.

The *Expedition Two* crew on ISS have been very active with the school program, and many Amateur Radio contacts have also been made with crew members. AMSAT and ARISS have received a thank you letter from Dennis Tito, KG6FZX for AMSAT/ARISS assistance while he was aboard the ISS. His letter reads in part "You made it possible for me to share my deep feelings of joy and fulfillment. I thank you very much for making my spaceflight so much more meaningful for my family and me."

Since the problems with AO-40 back in December, the worldwide network of controllers have managed to reestablish communication with the satellite and have enabled great communication using the S-band downlink and both the U-band and L-Band uplinks. On the first day of communications I was pleased to talk to many stations who were ready for these modes, including stations in Australia, New Zealand, and Japan.

Certainly the Geosynchronous Transfer Orbit (GTO) that AO-40 is in provides excellent communications for long periods of time, and will, I hope, be used in many future satellites. In addition to the SSB communications systems on AO-40, the General Beacon and RUDAK signals can be received on their publicized frequencies. I anticipate that AO-40 will provide us with a long life and a *Beginners Satellite for S-Mode*.

Since our Board of Directors meeting in February, AMSAT has been discussing the merits of a new satellite, which will be launched sometime in the next 2½ to 3 years. In the true AMSAT tradition there will be some straightforward operations combined with some experimental work on this satellite. Details were worked out in mid-July when the designers and builders met in Denver, CO. There is however one outstanding principle that the Board have laid down - *Keep It Simple*.

The Board of Directors, considered many options at their meeting, but decided that AMSAT should remain at the forefront of design and technology, helping to move our hobby forward in technology while avoiding unnecessary complexity. This means that we would no longer consider Mode A to be within our mandate, but we would encourage other organizations (universities, other AMSAT organizations, etc.) build and launch such satellites.

We are looking to include TDMA (Time Division Multiple Access) into the next satellite, and we hope to have a demonstration of this at Dayton next year. At that time we would be able to define the equipment required to make TDMA communications.

Now the Big Question: How much will this satellite cost, and where do we get the dollars? A detailed budget will be developed over the next few months, but already it is apparent that the biggest expenditure will be the launch cost. We will get competitive figures from several launch agencies, (that has already started) and develop our other costs of design, building, testing etc. Where do the dollars come from? - The Amateur Radio community, specifically the future users. How can you participate almost painlessly? By contributing to the AMSAT-NA President's Club (please see the advertisement on page 2 of this issue). All contributions go directly to the Project Fund. Currently there are two levels of contributors - Gold who provide $100/Month and Silver who provide $50/month - support AMSAT and choose your level of contribution. Call Martha at 301-589-6062 she will be pleased to arrange your monthly contribution.

73,

Robin Haighton, VE3FRH
President ■

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[continued from page 1] computer clock reset methods with four different types of UTC time sources. It also includes computer clock drift-correction algorithms, resulting in extended periods of use without reset.

The Goals of Satellite Tracking

The goals of satellite tracking are to determine at the observing Earth station (a) antenna pointing angles to the satellite in elevation and azimuth, (b) Doppler frequency shifts for uplink and downlink, and (c) Mean Anomaly (MA) phase for satellite mode operation. Generally, the most demanding in accuracy is the Doppler frequency shift. A frequency error of approximately 150 Hz or less is required for SSB, CW, and most digital modes. NASA-compliant orbit propagation models, such as SGP4, for Low Earth Orbit (LEO) satellites, and SDP4, for Molniya and deep space geostationary satellites, allow very good satellite Doppler shift computing if Keplerians are kept up to date. What is also required is timekeeping with appropriate accuracy. The required time accuracy is dependent upon the highest band of use, because Doppler shifts increase with frequency. LEO satellites have more Doppler shift because they move faster. Table 1 summarizes the required maximum error on the tracking clock to maintain the 150 Hz maximum error mentioned above, providing everything else is perfect. This table assumes an orbit similar to the Space Shuttle for the LEO case, and an orbit similar to P3D at apogee in the Molniya case. A Molniya satellite at perigee can be approximated as a LEO case. These numbers were obtained by running tracking software (see Reference 2) and noting the Doppler shifts as a function of the time error for each band.

The PC Clocks

The easiest solution to obtain time for the tracking software is to use the computer internal clock system. This clock system is actually made of two different clocks: one is the hardware CMOS clock, the other is the interrupt-driven software clock (see Reference 3). The hardware CMOS clock is a backup clock. It is always powered up, either by the power supply when the computer is operating, or by a lithium battery when the computer is turned off. It is not the clock used by the tracking software.

The software clock, which is used by the tracking software, is implemented directly by the CPU, and is interrupt-driven. This clock is actually a long integer 4 byte tick counter, located in low memory. It is incremented a number of times per second, through the next to highest priority (IRQ0), by the computer interrupt controller chip. The way this counter gets incremented is different between DOS, Windows 95/98, and Windows NT/ 2000/ ME. Under DOS, this counter starts at zero at midnight, and is incremented by one tick every 54.9254 ms up to a count of 1,573,039, occurring 23 hours, 59 minutes and 59.999 seconds later, at which time it rolls over back to zero. Under Windows 95 and 98, the tick counter starts at zero when Windows is first loaded, and gets incremented as in DOS, until the long integer rolls over, which will take a long time. Under Windows NT, 2000 and ME, this counter also starts at zero when Windows is first started, but is incremented approximately every 10 to 20 ms until the long integer rolls over. The average drift of the software clock can be from tenths of seconds (excellent machine) to tens of seconds per day (bad machine).

Band	LEO sat.	Molniya sat.
VHF	2 s	2100 s
UHF	0.7 s	700 s
1.2G	0.2 s	240 s
2.4G	0.1 s	120 s
5.6G	0.05 s	60 s
10G	0.03 s	30 s
24G	0.01 s	10 s

Table 1. Maximum Allowable Time Error for Satellite Tracking at 150 Hz.

PC Clock Performance

One observation can be made now: the accuracy of the DOS and Windows 95/98 software clock is limited to 54.9254 ms, and to 10 to 20 ms for Windows NT, 2000, and ME. Actually, if the reset is done properly, we should expect a maximum error due to the operating system of roughly +/- 30 ms and +/- 5 to 10 ms respectively. This implies that the built-in computer clock running under DOS, Windows 95 and 98, will not support the LEO 5.6, 10 and 24 GHz bands (per table 1), as those bands require an accuracy which is greater than the clock tick resolution. Windows NT, 2000, and ME will however support the bands up to 24 GHz for all satellites. This leads to a first conclusion: for the most accurate satellite tracking, Windows NT, 2000, or ME will provide from 3 to 6 times better time accuracy than Windows 95/98. This is of course assuming access to a perfect UTC time source for the reset.

The observation that comes next has to do with clock drift. This drift comes from several sources, the biggest being the fact that computer crystal oscillators do not oscillate on their designed nominal frequency, which makes them fast or slow over time. Most do not have any means of frequency adjustment. The drift obtained will also vary with the temperature inside the computer, and to a smaller additional amount with power supply variations. However, to a large extent, this drift is consistent for a given machine, and therefore can be mostly calibrated out. The computer I use for software development has a clock drift of exactly 1.967 seconds per hour, after a thermal stabilization of 30 minutes or so. This is one of the worst I have seen. It will not even support VHF LEO operation as soon as one hour after the clock has been reset perfectly to UTC. It is clear therefore that not only the clock will have to be set to UTC but, in addition, either it will have to be reset frequently, or the drift needs to be corrected. If not, it will become very quickly useless. The clock software will have to include some means for drift control and/ or correction. Finally, all operating systems maintain software clock registers containing year, month, day, day of week, hour, minute, second, and milliseconds, which are kept internally in UTC, and use the TIMEZONE parameter, set in Control Panel, to convert to local time.

WINTICK Software: First Exposure

The WINTICK program described in this article is designed to function on any machine running Windows 95, 98, NT, 2000, or ME. It does not support DOS or the older 16

bit Windows 3.1 because those are not multitasking operating systems. When started, it automatically recognizes which platform it is running on and will implement the correct algorithms for that platform. A serial port will also be needed, and/or a modem, to access the time sources. The computer will also require a sound card to provide the audio ticking schemes. Information on obtaining the program is given at the end of the article.

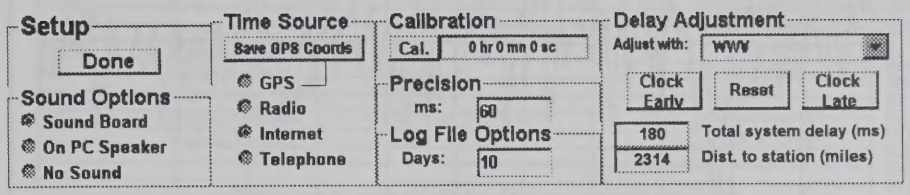


Figure 2. Setup Screen.

After proper installation and first start, WINTICK will appear similar to Figure 1 on the computer screen. At this point it will display whatever the computer clock is loaded with. Clicking with the mouse on AM/PM toggles the display from AM/PM to 24 hour mode. Clicking on Local toggles the display to UTC. Clicking on the Exit button terminates the program. Clicking on Taskbar sends the program there, where it executes in the background, maintaining an accurate system clock for the tracking software running in the foreground. The time is displayed in grey when the clock is neither synchronized nor calibrated, or in blue when it has been synchronized with a time source but not calibrated, and in yellow when it is both synchronized and calibrated.

Several things have to be set up first, by clicking the Setup button, which brings up the setup screen shown on Figure 2. A drop-down box, on the right of this screen, is used to select the ticking scheme that is sent to the sound card. The ticking schemes mimic the sounds produced by a number of time-distribution radio stations and telephone audio time services in the world. On the distribution disks, the ticking scheme default is WWV Fort-Collins, CO. There are 13 other choices possible (try them), including among others CHU Ottawa Canada, BPM Pu-Cheng China, JJY Tokyo Japan, etc. The audio schemes have been recreated from Reference 4. Some of those have been heard and confirmed, some have not. There is one more thing that this selection impacts. We will see later that WINTICK lets you either acquire automatically (in the GPS time source case), or enter yourself (in the other time source cases) your computer latitude and longitude coordinates. When this has been done, the distance between your computer and the time radio station selected is displayed. It will also delay the audio ticks delivered by the computer sound card to account for the propagation delay due to this distance, based on 5 ms per mile. This delay is not exactly correct because it actually depends on the band and propagation mode. It is however close enough for the accuracies we are looking for. We will see later that the audio ticks can be used to calibrate the various time offsets, which exist in the system by comparing the ticks coming out of the machine versus the ticks coming out of a radio receiver.

In the center of the Setup screen, the maximum amount of time which the machine has ever been calibrated for drift is displayed. A reset log file is also maintained, keeping a record of several parameters at every clock reset. The number of days of retention can be selected there. This log file can be displayed by clicking on the View Log button on the front of the clock. On the left of the Setup screen, the time source can be selected by double-clicking on the appropriate button, along with choices for the audio output. When the Done button is clicked, all the options selected are saved to disk and will be used until changed again. To conclude, an autostart feature is also available if the proper command line is inserted in Windows, Start Programs category. In this case, WINTICK will start automatically at boot, reset from the selected time source, and then go to background mode on the taskbar.

Time Sources

We need first to reset to UTC, using accurate time sources traceable to NIST (National Institute for Standards and Technology). WINTICK supports four different time sources: Telephone (through modem), the Internet (through your ISP), GPS receivers (through COM port), and LF/HF radio receivers (through COM port). We will start with the GPS time source option.

The GPS System

GPS, as its name suggests, is a positioning determination system. Can GPS provide time also? Well, yes, and it is actually used this way by many applications, like synchronization of computer networks, and cell phone systems such as TDMA and CDMA base stations as well as trunked two-way radio systems. A detailed review of how GPS works exceeds the scope of this article, but we can describe quickly what happens when a GPS receiver synchronizes with the GPS constellation. First, each GPS satellite includes onboard a high-accuracy atomic clock, which is kept, calibrated to GPS Time by Ground Control. Each GPS satellite repetitively transmits, among other things, its Keplerian data, and a GPS Time tick mark, along with GPS Time identification of what this tick mark was.

The receiver on the ground uses the Keplerian data to compute where the satellite is, and compares the tick mark time identification with the actual time of arrival of this tick mark at the receiver. This allows the GPS receiver to determine how long it took for this tick mark to travel from satellite to receiver. Then, the distance between the satellite and the receiver can be computed, using the speed of light. If this process is repeated a number of times with different satellites, at different locations in space, the ground receiver position can "triangulate" itself. Theoretically, it would take 2 satellites to obtain a two-dimensional fix (lat/lon), and three satellites to obtain a three-dimensional fix (lat/lon/alt). In practice, it takes one additional satellite because the receiver has no initial knowledge of GPS Time. Three satellites are therefore necessary for a 2D fix, and 4 satellites are necessary for a 3D fix to resolve the time unknown.

The net result is that the GPS receiver ends up "knowing" GPS Time, which is very accurate (the error is down to a couple hundreds of nanoseconds). However, what is really required is UTC, not GPS Time. The difference between the two is the "leap seconds" adjustment. As the Earth's rate of rotation is slowing, UTC time is periodically adjusted by the introduction of leap seconds at the end of June and December as required. GPS Time is never adjusted. As of January 1st, 2001, UTC was behind GPS Time by 13 leap seconds. Leap seconds are also broadcast by the GPS system along with the constellation Keplerians and the time tick marks.

GPS Receivers

For time applications, GPS specialized receivers can be procured for instrumentation, telecommunication and computer industries. Those receivers are generally plug-in boards, which will complement the PC clock system

Figure 3. Garmin GPS-3 Text Out Mode UTC Transfer Performance (Windows 95).

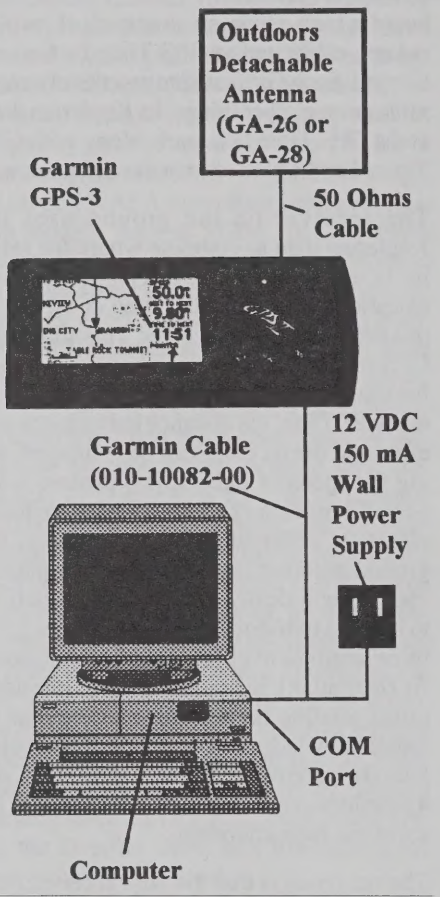


Figure 4. Garmin GPS-3 Setup.

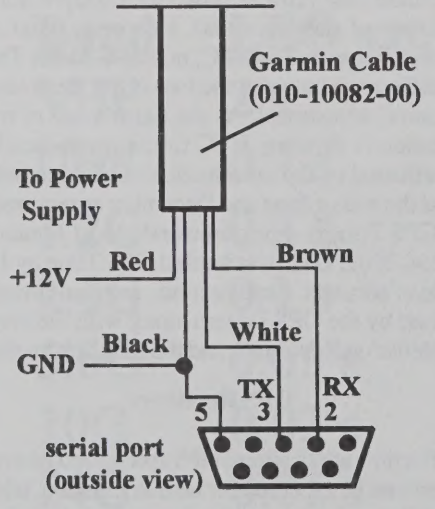


Figure 5. GPS-3 Port connections.

with a super-accurate GPS-synchronized time source. The good news is that those boards provide sub-microsecond accuracies. The bad news is that their cost is anywhere from several thousands to a couple tens of thousands of dollars. If you can afford them, they come with their own PC driver software, so WINTICK is not needed.

What about the low-cost (couple hundreds of dollars), handheld GPS receivers used by the general public? Theoretically, if they have a computer connection port, couldn't they transfer time? All of them generally implement time transfer to a computer through a COM port, using a protocol known as NMEA 0183 (National Marine Electronics Association, see Reference 5). A requirement of ship minimum GPS navigation platforms is that those receivers must support NMEA 0183 instruction sentence GPRMC, which downloads UTC date and time, longitude, latitude, and a host of other things. However, there is a catch here: although GPRMC defines time at the tens of milliseconds level, no cheap GPS receiver that I am aware of actually downloads anything more accurate than at the second level. The computer would then be reset with a precision of +/- 1-second worst case. Although this doesn't sound too good, it would actually support VHF and UHF LEO operations, and more importantly, it would do so worldwide as the coverage of the GPS constellation is worldwide.

Some GPS receiver manufacturers have also implemented their own protocols. One such manufacturer is Garmin, who, in addition to NMEA, proposes two more protocols, which actually provide much better results. Depending on the receiver model, Garmin proposes the PVT serial port protocol (see Reference 6), which is implemented on models GPS-3, GPS-3+, StreetPilot, E-Map, and E-Trex. Another protocol Garmin offers on some models is the Text Out serial protocol (see Reference 7). Garmin models GPS-3, GPS-3+, E-Map, and E-Trex support this format. To my knowledge, two other popular Garmin receivers, the GPS-12 and the GPS-2/2+, do not support either PVT or Text Out, only NMEA.

Although not guaranteed, both the Garmin PVT and Text Out formats can transfer UTC with sub-second accuracy as can be seen in Figure 3. This graph represents the errors obtained during a 24-hour period out of a Garmin GPS-3 in Text Out format. A single initial reset was performed at t = 0, then the GPS receiver time was read with WINTICK every 10 minutes, and compared to a well calibrated computer clock running under Windows 95. We can see that most of the time, the error is under +/- 100 ms (and this includes the +/- 30 ms of error due to Windows 95), with a peak at -200 ms. There is quite a bit of jitter, which is probably due to the way the data gets transferred out of the receiver. The receiver transmits the data once per second, and most likely the start of the Text Out packet is not locked to UTC. If the GPS receiver CPU is busy doing other things, like computing satellite positions, or updating the LCD display, some jitter may occur on the serial transmission start. I did not contact Garmin on this, but it probably could be improved by locking the packet start to UTC within the GPS receiver software. Nevertheless, Figure 4 shows an implementation that I use with a GPS-3, which has given good results. Figure 5 shows the connections between the Garmin cable and the computer COM port.

WINTICK GPS Support

Clicking on the GPS button on the setup screen of Figure 2 brings up the GPS setup screen. The GPS protocol can be selected there to use (NMEA GPRMC, Garmin PVT, Garmin Text Out - more could be added in a later revision if necessary), the COM port to use, and the timeout value in case of no answer. On Figure 4, a Garmin external antenna is used to improve reception of the satellites. This is an area which will probably require additional work. Garmin proposes two remote antennas: one which can be operated with 10 feet of cable, and another, which includes its own preamplifier, which can be operated up to 30 feet. There is a concern that the GPS receiver, or the preamplified remote antenna, could be desensed in the presence of a strong uplink transmitter signal nearby on the same antenna site. Some evidence of this was obtained by keying a 1.2 GHz HT in close proximity to the GPS antenna. If this is the case, a high dynamic range, filtered preamplified GPS antenna will have to be designed, to avoid losing the GPS satellites, or even worse destroying the GPS receiver front-end through overload. Finally, on the setup screen of Figure 2, clicking on the Save GPS Coords button will store the computer coordinates, which can then be used to compute the distance to the radio

station used for the reference audio ticks.

In conclusion to this GPS section, handheld GPS receivers will not provide the best time transfer precision (+/- 100 ms for Garmin models which support PVT and/or Text Out, +/- 1 second for others in NMEA mode). But, they are inexpensive, small, and more importantly, such a setup will work anywhere in the world, and be able to support satellite LEO operations up to mode LS.

LF/HF Radio Time Sources

The second type of time source supported by WINTICK is a number of LF and HF radio receivers synchronized to time dissemination radio stations such as WWV. Table 2 shows a list of such stations in the world, which transmit not only audio ticks, but also some type of time information that can be decoded by a suitable receiver (this list comes from Reference 4).

Time dissemination by radio is generally done in the LF band (Low Frequency, 30 kHz to 300 kHz), or in the HF band (High Frequency, 3 MHz to 30 MHz). Each band has its own advantages and problems. LF propagation is mostly ground wave, and exhibits less propagation variations. However, a sky wave mode may appear at night, which will reduce accuracy. Also, during summer, the LF band is subject to a tremendous amount of noise due to lightning strikes, which can be heard across thousands of miles. The HF band provides a hodgepodge of effects, depending on the part of the band used, the season, the time of day, and the Sun activity. The lower part of the band, up to 6 MHz, suffers from absorption during the day, but is still useful across a thousand miles or so. It can provide great skywave coverage at night. The upper part of the HF band, 12 to 30 MHz, propagates during the day through reflected skywave, and usually shuts down at night. Thousands of miles can be reached when it is open, but propagation delays are unpredictable. The mid part of the band, 6 to 12 MHz, is a mixed bag of the other parts, and may behave as either one. Different behaviors will be observed depending on the season and the Sun activity.

For all these reasons, radio clocks synchronize only a small part of the day, when they can receive the desired station. They may also take up to a day to synchronize. This implies that they include high quality oscillators, so that they can coast during the time of no signal. Worldwide areas of coverage are limited, subject to propagation at the instant, contrary to the GPS system, which can be relied upon anywhere, anytime.

Station	Location	Frequency	Coverage
WWV	Boulder (CO), USA	2.5, 5.0, 10.0, 15.0, 20.0 MHz	Northern Hemisphere, Americas
WWVH	Kauai (HI), USA	2.5, 5.0, 10.0, 15.0 MHz	Northern Hemisphere, Pacific
WWVB	Boulder (CO), USA	60 kHz	Continental US
MSF	Rugby, England	60 kHz	British Isles
DCF-77	Mainflingen, Germany	77.5 kHz	Europe
CHU	Ottawa, Canada	3330, 7335, 14670 kHz	Continental US
-	Allouis, France	162 kHz	Western Europe

Table 2. LF and HF Time Dissemination Stations

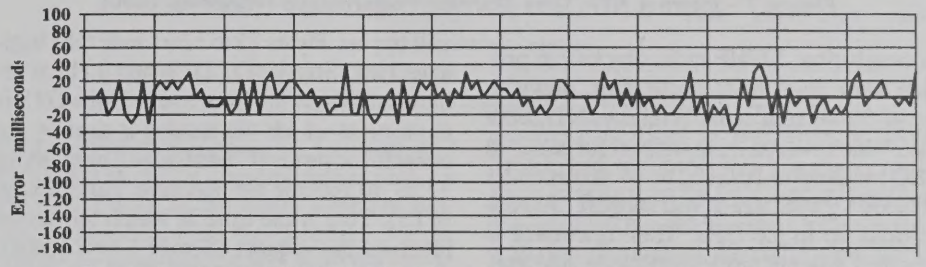


Figure 6a. Heath GC-1000 UTC Time Transfer Performance (Windows 95)

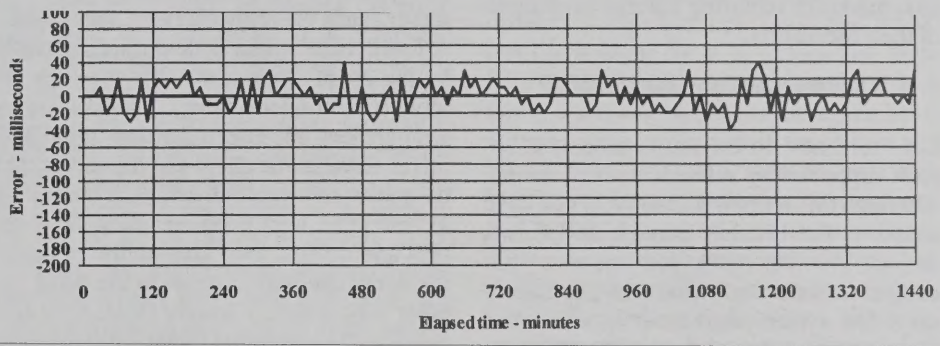


Figure 6b. Heath GC-1000 UTC Time Transfer Performance (Windows 2000).

LF/HF Radio Clocks

Older LF/HF synchronized radio clocks are generally specialized to decode a single radio station, i.e. WWV. Newer LF/HF receivers using programmable techniques like DSP may support more than one station, or even bands. Both generally connect to the computer through a serial COM port, and the protocols used to communicate with the computer are different for each type. They all provide good accuracies, 20 milliseconds or better. Figure 6 shows error runs similar to the one seen above for the Garmin GPS. For comparison, the scale used for Figure 6 is the same as the one in Figure 3. A modified Heathkit GC-1000 was used. Two runs were performed with this radio clock, one with Windows 95 (Figure 6a), the other with Windows 2000 (Figure 6b). As illustrated, the error is largely contained within +/- 40 ms in the Windows 95 case, and below +/- 15 ms in the case of Windows 2000. These two graphs clearly illustrate the superiority of Windows NT/2000/ME for this application.

WINTICK Support of LF/HF Radios

Each radio and/or manufacturer has its own protocol for communications between the radio clock and the computer. At the present time, WINTICK includes drivers to support the following radios: Heathkit GC-1000, SpectraCom 8170, Netclock/2 WWVB (format 0), Netclock/2 WWV (format 2), TrueTime 468, PST/Traconex 1020 (see Reference 8). Newer LF synchronized clocks have recently appeared on the market (US Atomic Clock, Junghans), but I did not explore those. If some include a serial port, drivers could be included in a future revision of WINTICK. Clicking on the Radio button of the Setup screen of Figure 2 brings up the Radio setup screen. The receiver type can be selected there, as well as the COM port and the timeout. Also, some of those radios do not provide the year; in this case the year can be manually entered. Contrary to GPS, those radios cannot supply your computer coordinates; they can either be entered on the setup screen, or the coordinates from a GPS time source can be used if they have been saved as explained previously. Finally, a word of caution when using HF radio clocks with antennas near your HF transmitting antenna. Protect the radio clock antenna input with diodes, or filter that input somehow to avoid the HF transmitter destroying the radio clock first stage (been there, done that).

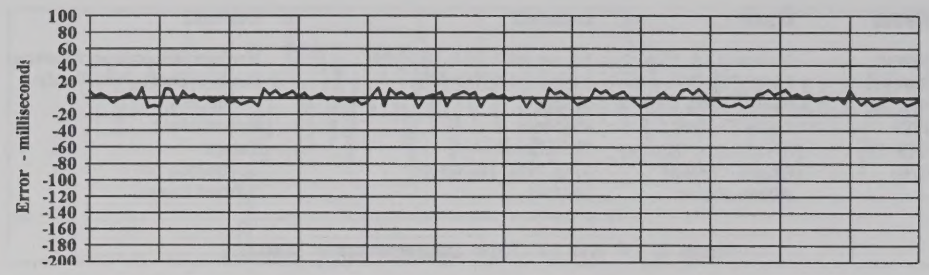


Figure 7 - Internet NTP Time Transfer Performance (Windows 2000)

In conclusion, LF/HF radio clocks can provide very good reset accuracies, down to the +/-20 ms area under Windows NT/2000/ME, which will provide support for bands in LEO mode up to 10 GHz, or +/- 40 ms under Windows 95/98, which will support LEO operations up to 5.6 GHz. Their drawback is that they will not work worldwide, and may actually synchronize only once or twice a day, therefore requiring careful calibration of their oscillators.

The Internet Time Source: NTP

Let's turn now to the third mode of clock reset supported by WINTICK: the Internet. Although this is not well known, if you have access to the Internet through an Internet Service Provider (ISP), you can reset your computer clock worldwide with good accuracy. The system used to do this is called Network Time Protocol, or NTP. NTP was introduced for the first time around 1979. Sponsored by DARPA and several other agencies and academic bodies, it is defined in the RFC-1305 Internet Request For Comments and several updates since (see Reference 9). The protocol uses a 48 byte packet containing, among other things, several time stamps, expressed in seconds, and fractions of a second, of elapsed time since January 1st, 1900, at 0 hour UTC. Those packets are sent back and forth between timeservers and time clients over the Internet, using the Internet standard User Datagram Protocol, or UDP-IP.

We will not review the meaning of every byte of the 48 byte packets, rather only what is necessary to understand how NTP works. Byte 2 represents the stratum of the Server or Client sending the packet. The stratum describes the status of the clock sending the packet. A 0 means undefined, not synchronized, or invalid. A 1 is the highest status possible: the clock is directly controlled by NIST, such as an atomic clock, GPS, etc. A stratum of 2 would mean a clock removed by one intermediate step from an NIST-controlled device, a stratum of 3 would be removed by two steps, and so on down to stratum 255. Bytes 5 to 24 describe several characteristics of the sending clock that we will bypass. Bytes 25 to 32 include the Originate Time Stamp (OTS). When a client requires time service from a server, the OTS is the time at which the request is sent by the client to the server (Client Clock Time). Bytes 33 to 40 include the Receive Time Stamp (RTS). This is the time at which the server receives the request (Server Clock Time). Bytes 41 to 48 include the Transmit Time Stamp (TTS). This is the time at which the server sends the reply (Server Clock Time). A fourth time stamp is determined directly by the client when it actually receives the reply (Client Clock Time). This is a clever arrangement, because, regardless of the time offset between the client and the server, and the packet transmission delays, it is possible to determine with good accuracy those delays and offsets. One assumption is made: the delay one way is equal to the delay the other way, which is usually close. NTP also provides for additional statistical algorithms to further improve this process, by working with more than one server, through averages, keeping track of various parameters representative of server behavior, etc.

WINTICK and NTP Servers

There are now thousands of NTP servers in the world. Most of them are maintained by private organizations, and their access requires authentication through the packets themselves (additional bytes after byte 48). To use those would require subscription to the service, or being part of the organization maintaining them. The current version of WINTICK does not support authentication. However, there are two more classes of servers, which allow public access and use. Some will allow use by the general public providing prior notification and approval through E-Mail to the server manager. Yet, others will allow unconditional access by anybody. WINTICK includes a database of approximately 100 NTP servers in the world. Only those servers that have declared themselves as having unconditional public access have been included. Additional servers may be found in References 10 and 11. However, be careful to "play by the rules" regarding those servers, which are not, listed as unconditional access. WINTICK does not implement the full version of RFC-1305, but rather a related Internet document called RFC-1361 (see Reference 12). RFC-1361 is a simplification of the full standard, which is well suited to our present application.

Figure 7 shows another 24 hour error run which was performed similarly to the previous ones, this time using NTP, and Windows 2000. From 0 to 480 minutes, one NTP server was used, and from 480 until the end, WINTICK automatically switched to another NTP server because the first stopped answering. The difference in behavior between the two NTP servers is evident, both in jitter and offset. This comes mainly from delay dispersion in the routing of the packets over the Internet. Errors can be expected to be less than the jitter (+/- 20 ms) combined with server offset (another +/- 10 ms), for a total of +/- 30 ms. Clicking on the Internet button of the Setup screen of Figure 2 brings up the Internet setup screen. WINTICK allows customizing the servers as a primary server, a first backup, and a second backup. The servers closest to your location should be selected from the database to minimize the delay dispersions.

Internet Access

WINTICK uses the standard WinSock operating system plug-in to access the Internet layer. Your computer can access the Internet through one of three methods: (1) Dial-up-Networking (DUN), (2) a Local Area Network (LAN), or (3) a direct modem connection to a service such as AOL. In DUN access, WINTICK has been found to work properly with several ISP's providing PPP-compliant servers (Point to Point Protocol). With LAN's, it performed well on an Ethernet LAN, and on a cable modem (RoadRunner). Direct modem connections will generally not work because they are not PPP-compliant (except Compuserve, which uses PPP). NTP will support LEO operations up to the 10 GHz band. The drawback of using this method is that the computer needs to be on-line on the Internet every time a reset is required. This may lack flexibility if the Internet link is sharing a telephone line. If a permanent link to the Internet is available, as with a cable modem like RoadRunner, this is a good solution.

The Telephone Time Source

The telephone is the fourth and last time source supported by WINTICK. Resetting the computer through the telephone line has been an option for many years, as references to it exist in the oldest satellite tracking packages released in the mid 80's. In the U.S., NIST supports a telephone computer time service called ACTS (Automated Computer

Time Service). This service is located in Boulder, CO, and in Hawaii, HI. This service supports only POTS (Plain Old Telephone Service, through modem), and cannot be used through the Internet. The service is free for use by everybody (NIST claims supporting up to 10,000 phone calls a day), but the cost of the long distance call is yours. However, the total duration of such a phone call will be less than 20 seconds in most cases.

When calling the ACTS time server, you will receive a succession of date/time ASCII time stamps, each one terminated by a star, which is actually the time mark for the time stamp received, at the top of the second. If the computer immediately sends back the star, the ACTS server can "measure" the telephone line delay, assuming it is the same in both directions, which most often it is. Then, the server will attempt to advance the time marker on the following time stamp to try to cancel the line delay. When it recognizes that the delay is approximately canceled, the star changes to a pound sign, and the computer clock can be reset at that time. The precision that can be obtained is excellent, 10 ms or better. Another 24 h error run similar to the previous ones was performed, on telephone lines between Boulder, CO, and High-Point, NC. It is displayed on Figure 8. As shown, the error is well below +/- 10 ms, the best of all methods reviewed so far.

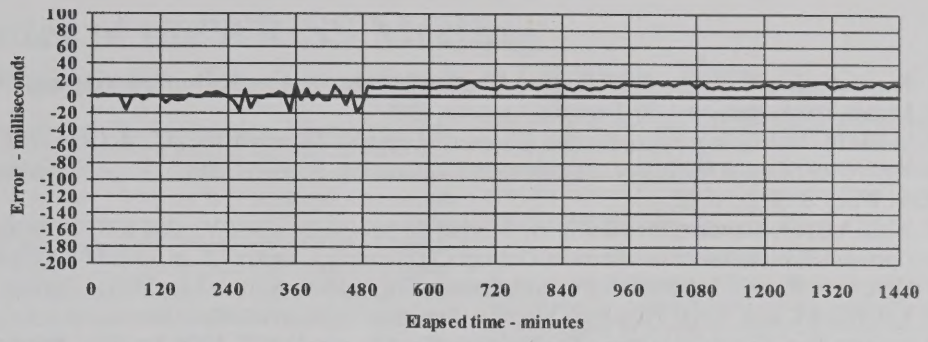


Figure 8 - Telephone ACTS Time Transfer Performance (Windows 2000)

WINTICK Support of Telephone

At the present time, WINTICK support of telephone time sources is limited to United States ACTS NIST service. There are similar services in existence in Europe, and drivers for those could be added in a future revision. By clicking on the Telephone button on the Setup screen of Figure 2, the Telephone setup screen comes up. The service to use can be programmed, Boulder or Hawaii, the modem COM port, the timeout, and the computer coordinates. As a conclusion to this section, ACTS will support LEO operations up to the 24 GHz band. The drawback of this method is that access to a phone line is necessary, and it costs a long distance phone call every time WINTICK needs to reset the clock.

Calibrating for Clock Drift

Now that we have four different methodologies for resetting the clock to UTC, the time has come to correct the clock drift. WINTICK includes a powerful calibration algorithm, which will provide a fast, yet accurate determination of the correction parameters. The calibration procedure is the same for all Windows platforms. The correction algorithms are also similar, but differ in their detailed implementations. Calibration of the computer clock is started by clicking on the CAL button on the Setup screen of Figure 2. The first time the program is ever started on a machine, it will reset the clock, then run for 30 minutes without any correction, then reset again, measuring the error. Correction coefficients are then computed and applied, and a new 30 minute run starts. At the end of it, the error is again measured. If the clock is within precision, no reset is performed, the machine is declared calibrated for the time spent since the last reset, and the run continues for another 30 minutes, at the end of which the cycle repeats itself. Alternatively, if the error exceeds precision, the clock is reset, new correction factors are computed and applied, and the cycle restarts from zero.

This calibration methodology allows calibrating by incremental chunks of 30 minutes. The precision used depends on the time source, and is indicated on the Setup screen of Figure 2. The calibration run can be stopped at any time, and whatever calibration data has been obtained so far is saved to disk, and will be used from then on. "Calibrated" means that the machine has passed the precision limit for the length of time indicated. A typical calibration will run for 24 hours or more, and will improve the computer drift by a factor of at least 100x to over 1000x (remember my "bad" computer? It went from an uncalibrated required reset every 109 seconds to a calibrated required reset every 36 hours - this is a 1189x improvement).

Canceling System Delays

A second correction is available to remove the various time delays that the system may have built-in (time delay in the time source, time delays in the COM port, time delays in the clock update process, etc.). Fortunately, these delays are constant, and can be "tuned out". After this has been done, the clock setting error will be the time source error plus the operating system error.

An original (and quite effective) way of doing this is to listen to WWV on an HF receiver, and compare WWV's audio to the audio coming from the PC clock. A dual channel oscilloscope can be used for this as well, with one channel on the audio card output, and the other on the HF receiver audio output. The delay cancellation method consists in determining which tick comes first, the PC clock tick, or the HF WWV clock tick. If the PC clock tick comes first, click on the "Clock Early" push-button once or more (see Setup screen of Figure 2), and if the WWV tick comes first, click once or more on the "Clock Late" push-button, until the PC clock and WWV ticks line up in time on top of each other exactly. Each time one of those two push-buttons is clicked, an internal delay is increased or decreased by 10 ms. When the ticks superpose in time, click "Done". The system delay will be saved on disk, and will be used at every subsequent clock reset. This delay is specific to each time source, i.e. there are independent saved delays for GPS, Internet, LF/HF Radio, and telephone.

Performance Results

The error runs previously presented in Figures 3, 6a, 6b, 7, and 8 tell the story regarding the achievable precision for the various time source types, and operating systems. Computer clock drift determination and subsequent automatic correction is the other major benefit of this software.

Disclaimer

The author of the WINTICK software and this article has no affiliation with any of the companies and/or agencies mentioned. A Web site that will allow download of WINTICK will be selected soon. Please contact the author via Email to obtain this Web site URL.

Acknowledgments

Thanks to the following individuals who have contributed in various aspects of testing this software: KQ4GX/Steve Flanyak, KQ4GW/Kathy Flanyak, KB1G, and Bill Boyes.

References

1. Programming Windows, Fifth Edition, Charles Petzold, Chapter 20, Multitasking and Multithreading, Microsoft Press, 1999
2. Instant Track, Version 1.00, Franklin Antonio, 1989
3. Inside PC Interfacing, Myke Predko, Chapter 20, Precise Timing in the PC, McGraw-Hill, 2000
4. Reference Manual for Telecommunication Engineering, Second Edition, Roger L. Freeman, Chapter 25, Standard Time and Frequency, John Wiley & Sons, 1992
5. NMEA 0183, Standard for Interfacing Marine Electronic Devices, Version 2.30, National Marine Electronics Association, 1998
6. Garmin GPS Interface Specification, Garmin Corporation, Chapter 7.5.26, D800 PVT Data Type, 1998
7. Garmin Software Upgrade Information, Garmin Corporation, Simple Text Output Format, 2000
8. Reference Clock Serial Timecode Formats, David L. Mills, available at *www.eecis.udel.edu/~ntp/*
9. Internet Time Synchronization: The Network Time Protocol, RFC-1305, David L. Mills, Revision 4, 1999, available at *www.eecis.udel.edu/~ntp/*
10. Public NTP Primary Servers, Stratum 1, David L. Mills, available at *www.eecis.udel.edu/~ntp/*
11. Public NTP Secondary Servers, Stratum 2, David L. Mills, available at *www.eecis.udel.edu/~ntp/*
12. Simple Network Time Protocol, RFC-1361, David L. Mills, available at *www.eecis.udel.edu/~ntp/*
13. Computer Time Synchronization, NIST SP432, Michael Lombardi, available at *www.boulder.nist.gov/timefreq/* ■

Satellite Orbital Elements

by Ray Hoad, WA5QGD

Satellite	AO-10	UO-14	FO-20	RS-12/13	RS-15	FO-29	AO-27
Catalog Number	14129	20437	20480	21089	23439	24278	22825
Epoch Time	1185.1587877	1186.1534626	1182.7486831	1183.2128472	1185.7645487	1183.2134775	1185.8740924
Element Set	814	725	323	346	553	425	20
Inclination	26.5087	98.3592	99.0555	82.9224	64.8182	98.5374	98.3481
RA of Node	264.5351	245.3886	248.4439	263.8415	281.7508	46.3892	233.5646
Eccentricity	0.6008082	0.0010876	0.0539749	0.0029453	0.0164581	0.0350819	0.0007821
Arg of Perigee	163.2676	157.4212	276.276	144.5342	223.8966	323.0637	208.5355
Mean Anomaly	231.6821	202.7448	77.7151	215.777	134.8784	34.6797	151.5398
Mean Motion	2.05866706	14.30734917	12.83293986	13.74274578	11.27541507	13.52775902	14.2843914
Decay Rate	-0.00000123	0.00000167	-0.00000009	0.00000112	-0.00000034	-0.00000037	0.00000175
Epoch Rev	13579	59762	53396	52187	26864	24067	40510
Satellite	AO-40	UO-11	AO-16	DO-17	WO-18	LO-19	UO-22
Catalog Number	26609	14781	20439	20440	20441	20442	21575
Epoch Time	1183.9776621	1186.5362676	1186.2470915	1186.6900320	1186.5435293	1185.7475751	1186.5540305
Element Set	104	547	527	516	544	523	249
Inclination	5.3717	98.0345	98.4032	98.4164	98.4134	98.4249	98.1239
RA of Node	176.3765	150.5342	253.7659	256.8206	256.2189	257.5004	199.8372
Eccentricity	0.799157	0.0009717	0.0010951	0.001121	0.0012018	0.0011962	0.0008402
Arg of Perigee	295.1287	321.1922	162.8572	159.6349	160.3406	162.2485	118.2583
Mean Anomaly	7.7538	38.8587	197.2944	200.5271	199.8242	197.9117	241.9453
Mean Motion	1.2541074	14.74125407	14.30862767	14.31080741	14.30955788	14.31102542	14.38191977
Decay Rate	-0.00000349	0.00001314	0.0000013	0.00000219	0.00000198	0.00000207	0.00000337
Epoch Rev	309	92874	59766	59778	59775	59768	52301
Satellite	KO-23	KO-25	IO-26	TO-31	GO-32	SO-33	PO-34
Catalog Number	22077	22828	22826	25396	25397	25509	25520
Epoch Time	1185.5203677	1186.5439798	1186.1979976	1186.8475774	1179.9092273	1186.5464327	1186.1109681
Element Set	13	980	4	528	937	344	399
Inclination	66.0868	98.3513	98.3533	98.683	98.682	31.4356	28.4604
RA of Node	289.7428	235.2454	234.689	263.7311	256.4154	258.0535	201.3785
Eccentricity	0.0013009	0.0009627	0.0008563	0.0003669	0.0002326	0.0362622	0.0006689
Arg of Perigee	230.6735	187.3594	210.106	67.1602	86.9141	170.5258	60.481
Mean Anomaly	129.3131	172.745	149.962	292.9964	273.2302	190.2428	299.6645
Mean Motion	12.8636837	14.29030028	14.28612076	14.23020783	14.22604409	14.25745571	15.08511191
Decay Rate	-0.00000037	0.00000159	0.00000193	-0.00000044	0.0000014	0.00000832	0.00001917
Epoch Rev	41789	37341	40518	15521	15422	14056	14771
Satellite	UO-36	AO-37	OO-38	WO-39	TIUNGSAT	SAUDISAT	ISS
Catalog Number	25693	26065	26063	26061	26548	26549	25544
Epoch Time	1186.6185906	1185.8738503	1186.3365401	1186.5429409	1186.6281072	1185.7558846	1186.9171828
Element Set	968	263	265	295	142	204	174
Inclination	64.5636	100.1925	100.194	100.1924	64.5597	64.5533	51.5722
RA of Node	21.5362	122.4512	122.9605	123.7619	48.1465	53.7788	353.9152
Eccentricity	0.0045303	0.0038056	0.0037559	0.0036509	0.0035073	0.0037042	0.0016167
Arg of Perigee	245.0624	156.3725	154.4378	151.4628	325.7077	343.0608	247.4553
Mean Anomaly	114.5767	203.921	205.8661	208.856	34.1743	16.9245	271.2807
Mean Motion	14.73859107	14.34647118	14.3469346	14.35704775	14.76979437	14.74641151	15.63746553
Decay Rate	0.00000112	0.00000231	0.00000225	0.00000606	0.00000987	0.00000944	0.00036806
Epoch Rev	11880	7522	7529	7536	4165	4147	15000

Minutes of the ARISS Meeting
Held at ESTEC in Noordwijk, The Netherlands, 04–06 May 2001

ARISS Delegates in Attendance

Frank Bauer, KA3HDO - AMSAT-NA
Rosalie White, K1STO - ARRL
Gaston Bertels, ON4WF, UBA - AMSAT Belgium
Thomas Kieselbach, DL2MDE - DARC
Jörg Hahn, DL3LUM - DARC
Ken Pulfer, VE3PU - RAC
Keigo Komuro, JA1KAB
Masanobu Tsuji, JH2PRZ
Sergej Samburov, RV3DR - AMSAT-RU, SRR

Moderator

Roy Neal, K6DUE - ARRL and AMSAT-NA

Observing

Lou McFadin, W5DID - AMSAT-NA
Ron Parise, WA4SIR - AMSAT-NA
Will Marchant, KC6ROL - AMSAT-NA
Carolynn Conley, KD5JSO - NASA JSC
Robert Whelan, G3PJT - RSGB
Luca Bertagnolio, IK2OVV - AMSAT-Italy
Miles Mann, WF1F, - MAREX-NA
Ghislain Ruy, F1HDD - AMSAT France
Jean-Louis Rault, F6AGR - AMSAT France
Wes Wysocki, SP2DX - PZK
Rodrigo Matias, CT1GQU - REP AMSAT
Antonio Sena, CT2GPW - REP AMSAT
Manfred Lugert, DL5FAB - DARC
Bertus Husken, PE1KEH - VERON

General Meeting

Meeting moderator Roy Neal opened the 04 May 2001 ARISS Meeting by welcoming all delegates and observers. He reviewed the meeting schedule and the agenda, asked Rosalie White to take notes and requested that all attendees to introduce themselves.

Roy spoke of how ARISS was born from ideas, and has turned into an adolescent; a goal of our ARISS meeting was to develop that adolescent into an adult through our teams learning to adapt...together.

Frank Bauer summarized notes from the ARISS meeting in December at Goddard Space Flight Center. Changes to be made to official Minutes include: Larry Agabekov, N2WW, replaces Boris Stepanov as Russian delegate, and re-inserting Ken Pulfer's name as Canadian delegate.

Frank reviewed the definitions of the following terms: ARISS delegates, representatives, observers and partner countries. He also reviewed: the delegate guidelines, names of officers, delegates, committees and committee members, along with working group interactions, the ideals of ARISS, and ways non-member countries can participate in ARISS, such as the South African contributing their work as a ground station.

Revisions to the charts were to be made as follows: for the Administration Committee chart, Gaston Bertels should be listed under Europe; for the ARISS US Team Organization Chart, add call signs for Carolynn Conley and Nick Lance; for the Operations Committee Members, revise Carolynn's call sign.

Delegates were reminded by Frank that they need to select a Vice Chair for each ARISS committee. Ken will determine if Robin Haighton has enough time to stay on the Hardware Committee. Frank stressed the need for delegates from Canada, Japan and Europe for the Operations Committee. (During coffee break, Luca Bertagnolio affirmed that Alberto Zagni wants to stay on the Operations Committee.) Masanobu Tsuji stated that Japan would soon select someone, along with a person for the School Committee. Frank reiterated that committee members must be from the region they represent, and asked delegates to contact Gaston, Frank, Rosalie or Ken with names of selected committee members.

Delegates agreed that our ARISS meetings should be publicized early enough to allow people to submit agenda items or comments. We should also publicize how proposals can be presented, and how they are reviewed for possible future approval.

School Operations: Will Marchant

Will provided a status on school operations. He reviewed the unanimous decision of delegates in December that it was appropriate to first schedule QSOs for the 1996 U.S. schools. Delegates decided this was appropriate; it allowed for school QSOs to be done while hams were being named to the ARISS School Committee, and while the committee was getting organized. It also allowed us to use the oldest schools (which were USA and Canadian) as a test-bed for problems and errors with the ISS QSOs.

Once each region has a member on the school committee, the committee will review all school applications that their regions have approved. The committee will turn over a list of approved schools to the Operations Committee. The Operations Committee will schedule the school QSOs into slots of ISS crew time. A ham from each region is needed to interface with Will for scheduling crew time. ARISS does not specify which crewmember does the QSO unless the school was picked by a particular crewmember.

Currently, NASA is not billing ARISS for our QSOs against their block of educational time. The U.S. astronaut crews are scheduled for school QSOs during the 40-hour workweek, Monday through Friday.

Sergej Samburov: The cosmonauts do not have school contacts listed as part of their official duties in their contracts. On *Mir*, school contacts had to be a volunteer activity by the cosmonaut during free time. The ARISS team will need to operate within these conditions if cosmonauts do school contacts. One Russian school is interested in doing a QSO.

WWW Pages: Ken Pulfer

Ken suggested that our WWW home page should include our logo, ARISS objectives, links to ARISS WWW pages in other languages, and the space agency agreements. He would like for the information to include an overview statement of ARISS, the board and committee members' names, links to current news, the launch schedules, ARISS call signs, the QSL card, crew names and call signs, ARISS frequencies, an FAQ, school contact information with an application, a school check list, and where to find country-specific information.

Each region's WWW pages should have some consistencies, such as our logo, some general layout and a similar format — several issues will have to be addressed. Volunteers are needed for various work on the Web; please have volunteers contact Ken or Will. *Ken and Will are doing the English version. Canada has the challenge of needing information in both English and French. Christopher Mercier in France is working on some of the multilingual aspects.*

Each country's site should have regional news that is not on the international page; this will minimize time needed to translate items for the international page. Minutes of previous ARISS meetings should be easy to locate. The Webmasters would host the pages in their respective countries and link to other regions' WWW pages. Recognition of international space organizations, commercial companies and amateur clubs and individuals is needed; we could coordinate a posting of "special thanks" in a conservative manner.

Legal Issues: Gaston Bertels

Legal aspects of liability and territorial status of the ISS provide possible legal challenges for ARISS. The European Center for Space Law (ECSL) is available to ESA. ECSL, Andre Farand, reviewed the legal aspects of ISS. The law of each state applies to that state's ISS modules. Each partner region (Russia, US, Japan, Canada and Europe) maintains jurisdiction and control over the flight elements (modules and other ISS elements) they provide to the ISS, and for their national personnel. Article 16 of the IGA (Intergovernmental Agreement concerning cooperation on the ISS) establishes a cross-waiver of liability. Nevertheless, any individual could put forward a claim, but the defendant would invoke the cross-waiver of liability before the court. Since the hardware is always certified for flight, it would be rather difficult to prove a default as the origin of an injury. Thus, the chance for a suit is rather theoretical. The plaintiff might sue in the country he had the greatest possibility to win his case. For example, the radio operating in the Russian Segment – FGB using an American radio, might sue under USA law, rather than Russian law.

Probably what is most important to ARISS would be if the ARISS equipment injures the crew while they are using it, rather than the crew damaging the ARISS equipment. Liability of ARISS member societies is covered by their respective insurance policies.

Japanese Delegation Report: Keigo Komuro

Japan's government issues Amateur Radio station licenses and operator licenses. Future ISS Japanese crewmembers will get US ham licenses and Japanese operator and station licenses. (On STS-47, Mamoru Mohri used his own call sign and spoke Japanese for Japanese schools and his general QSOs.) A Japanese youth group has submitted an ARISS application. The first Japanese school contact could be done in English if there are no Japanese astronauts on-orbit at the time.

Review of Recent ISS On-the-Air Activities: Will Marchant

The Expedition 1 crew performed school QSOs, personal family/friend QSOs, and limited general QSOs. The first two schools experienced a few technical problems during their QSOs. We also had several scheduling problems with NASA for school QSOs. Besides selecting US schools from 1996, a Canadian school that had also applied in 1996, was scheduled for a contact — all were satisfied with

their QSOs.

The Expedition 2 crew has done a more-balanced mix of school QSOs, family/friends QSOs, and general QSOs. There are still some scheduling problems with NASA, and often we do not learn more than a few days in advance the final date selected for the school QSOs.

We need to determine what languages the Expedition crews speak, and what languages the school students can speak, and then review third party problems.

Sergej Samburov: The Expedition 1 cosmonauts felt that the setting up of the ham equipment was very important for the ISS. All cosmonauts for the next five years have ham licenses, and call signs will be provided to the ARISS group.

Antenna System Status: Frank Bauer

The present ARISS antenna configuration consists of two antennas – installed on the nadir and zenith sides of the FGB (Zarya) module, for the 2-meter band. The plan is for 4 new antenna systems to be installed on the aft end of the Service Module: for 70 cm, 2-meters, L-band and S-band. The L/S band antenna is a flat spiral antenna. The Italians built the microwave antennas and diplexer; the US built the mounting plate and the VHF/UHF antennas, plus taking on the full integration for all hardware. The Russians built the handrail clamp and interconnecting cables.

The antenna systems are currently scheduled for STS-105 /7A.1, which is launching in mid-July 2001. Sergej displayed the yellow fabric cover, green Velcro straps to uncoil the coiled cables, and one EVA connector for everyone to see. The preliminary design review was 20 March 2001 and the CDR was 03 April 2001. The hardware delivery date was 15 April 2001, and Carolynn Conley secured two extensions for delivery. Mid-January 2001 the US side was asked to fund, finalize the design, make the drawings, fabricate and launch new hardware: a frame, 4 handles, and a new slot to the frame. Three weeks ago, on 24 April 2001, two additional changes were communicated: move 2 antenna locations and raise the antennas by a 10-degree tilt or with shims. The ARISS-US team recommended to NASA to de-manifest the antenna systems from STS-105, 7A.1, and to find alternatives. There just is not enough time to complete the required tasks, including making the hardware changes, changing the drawings, testing, certifying, getting approval reviews and completing the safety data package.

Sergej Samburov: He said finding other flight alternatives won't work, because only one crew is trained for the EVA. The cables in the SM are already installed; the equipment in the SM will be near a table and a window. Concerning the new specification for a 10-degree tilt, Sergej feels we can resolve this change requirement very easily. We have the length of one cable, which is sufficient.We were given a tolerance specification of +/- 5 cm for the other cables, and their lengths are not as important. Near to the ham antennas is another antenna. At the place where we would install them, the Japanese equipment is very close to the handrails for the ham antennas. To avoid interference, we had to put more space between them, and the bend of 10 degrees solves this problem. The construction of the antennas has not changed. The main problem is that we have already trained the crew to install these. To switch to a new crew would result in a loss of efforts and money. The Russian side is interested in getting signals from the antenna during EVAs. Also, the Russian team got the crew very interested in doing this EVA work. The crew was even given ham radios for home to train with. The Russian side found an opportunity in the EVA schedule for installing the antennas – we don't get a dedicated EVA for this. Removing the antennas from 7A.1 will cause a delay. If the antenna installation is delayed, there will also be a delay of installation of hardware on the inside of the ISS. Also, time will be needed to find and train another crew. The delay will keep HF and 70 cm operators from happening; the crew can't do dual ops.

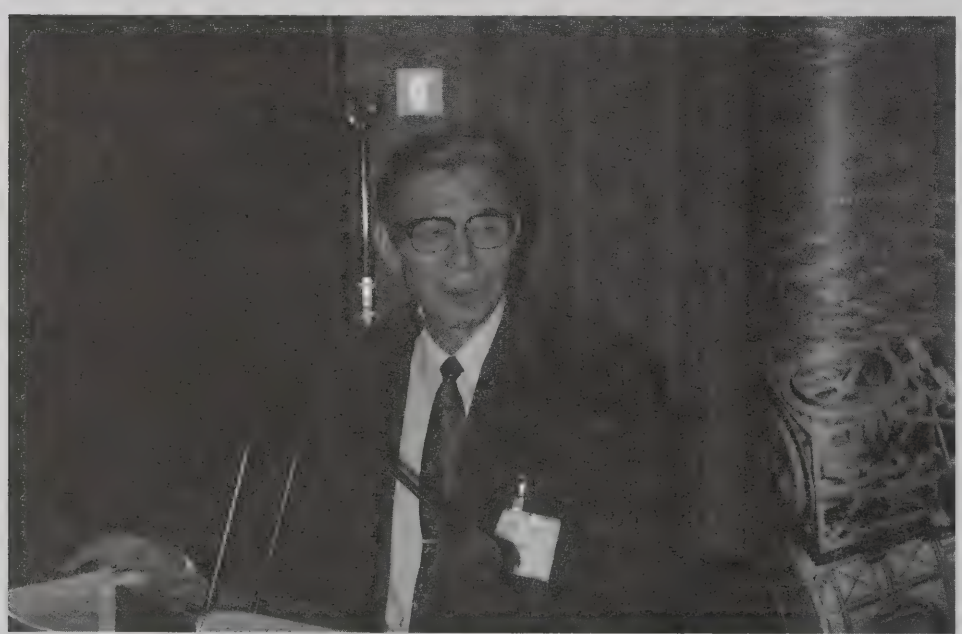
Frank Bauer's Comments: If we do a partial shipment of currently completed hardware to Russia, there is a very lengthy hold-up in Customs. We will get no quicker results than if we waited and sent all of the finished equipment on a later shuttle flight.

The antennas have had several system changes; since January 2001. We have had to build the handles and frames and change the plates several times. Painting and paint-curing takes two weeks, silk screening takes 3 weeks. The changes can't be completed in time to make a delivery of 15 June 2001. The safety people cannot keep up with the changes. We haven't done an end-to-end test of the antenna system. Preparing just one antenna takes as many weeks as doing all four together.

With possible delays in Progress, we may not be able to use the July shuttle flight, anyway. There could be a crew delay or shuttle delay, and the result would be that the trained crew could still be doing the EVA.

The types of problems we've had show that it is very important we hold an ARISS meeting every six months to define requirements and set specifications. Misunderstandings have developed because some delegates have missed meetings, and not received important information.

We need to ensure that our antenna systems are ready and certified prior to flight. We would lose a tremendous amount of goodwill from the space agencies if we fly equipment that is not ready for flight or has not been fully tested. We need to freeze changes, set deadlines, do a mini-review, complete the fabrication, integration, and tests. We should not ask NASA to re-manifest until we know we are ready.



Keigo Komuro, JA1KAB making a presentation at the ARISS meeting.

Review of Hardware Proposals

Slow Scan TV (SSTV): Miles Mann

SSTV was very successful years ago on the Shuttle and more recently on *Mir*. The development of the Spacecam1 SSTV project is 98 percent complete. Two IBM 760 computers were purchased by MAREX and used as test platforms for SpaceCam1 (the 760 is similar to the NASA SSC computer). IBM has unique hardware: the SpaceCam1 requires 60-70% of the IBM 760 cpu capability and .jpeg is the only extension possible. Lou McFadin manufactured a hardware interface box that goes between the audio port of the laptop to the radio. It gets power from the radio. The picture comes from the laptop to the adapter, which sends a warning to the radio for transmissions, then the signal is transmitted. SSTV will be on 2 meters. Our long-term plan is to put packet on 70 cm. Two Spacecam1 features currently are not enabled until the next release on 01 June 2001: Guest Text and Disk Size limiter. The current missing features are only cosmetic features and will not require big changes to the current software. Miles is ready to do paperwork to help manifest this proposal.

Johnson Space Center will have many questions for Miles, since they will have to integrate the software into the flight load

The ARISS group needs to decide how much time the crew should spend with SSTV versus packet.

IDEFIX (Hand-launched PICOSAT): Ghislain Ruy, AMSAT-France

IDEFIX is a satellite that could be deployed from Space Station by an EVA crew person. The satellite has a strap handle that the EVA crew person uses to carry the box and deploy (approximately 10x40x60 cm). It will be painted black on the inside and the outside must be reflecting aluminum. Weight is around 3-5 kg.

IDEFIX fulfills the following ARISS mission objectives: service Amateur Radio community and help fulfill educational requirements. IDEFIX would allow ease of reception on the ground, and children could perform scientific studies.

IDEFIX is highly modular and easy to reproduce; many configurations are available. It could be deliverable within two months. It would require minimal crew training and minimal operations for deployment in space. It would have a space lifetime up to 60 days or more with reduced onboard experiments. Experience from previous satellites resulted in good use by some schools, and interest from the general public from the impressive deployment pictures.

Some costs for IDEFIX are low since crew training won't change and new training units aren't required. The safety system is also fundamentally the same for all units and does not require new engineering units. IDEFIX is a low cost project: less than $1000US per unit. The safety aspects were taken into account at the very beginning of the design process. The battery model flew in three previous missions and has been used onboard *Mir.* AMSAT - France has presented a fully operational demonstration unit that is available for further presentations. Some concerns were raised about whether ISS officials would allow the deployment of a satellite from the ISS. The primary rationale behind these concerns is potential collision with the ISS.

This project came from Sergej's Sputnik 4 project, and would not be a replacement for the other European Digitalker project.

International Agreements and Manifesting: Carolynn Conley

The Russian and US sides developed three agreements to implement Amateur Radio on the ISS. The international amateur community is now working to include all the ISS international partners into the Amateur Radio program. Since ISS Ham is under crew psychological equipment, the only agreement that will be needed is the Technical Team Charter.

Manifesting requires two years of advanced planning. Right now the replacement packet module is being manifested, then the antennas are the next system to be sent up. Then a computer and the SSTV could be manifested about 9 to 12 months from now. The ARISS international team must identify the hardware for the future.

ISS Ham Radio Hardware Development: Frank Bauer

The ISS ham shack is not like private or club ham shacks. There are many constraints for the ISS ham station including the varied desires of the station crews, the constraints imposed by ISS program management, the desires of the international Amateur Radio community, and the ITU requirements that must be met for international Amateur Radio stations. There are many more safety, operations, interface and legal regulation requirements for operating Amateur Radio from space than from the ground.

The ARISS group now needs to set up requirements, and design review sessions where everyone understands the needs for interfaces, volume/mass restrictions, capabilities, and drawings. These need to be understood before anyone begins fabrication of any proposed or approved project. We need more specifications to give developers beforehand, similar to how the antennas were planned, designed and built.

To smooth out this process, the requirements must be carefully developed, reviewed and selected. Projects must be approved (in writing) to be placed on the space station. Thomas Keiselbach pointed out that a prototype is very helpful for reviewing hardware proposals. There was a proposal presented in 1998 where 12V was required from the radio, but only 7.5V came out of the radio adapter. That is why interfaces must be defined in writing. ARISS-Europe approved the proposal of Thomas in September 2000. This was discussed at the December 2000 meeting, but a problem developed - there is no space in the Russian segment according to Sergej. The ARISS group needs to talk together much more often to stop problems before they grow. The ARISS group must understand problems and fix them together. We need more co-engineering. We need to work as a team that shares information in parallel.

ARISS is a small group with limited resources; it is difficult to complete all tasks with just volunteers. It is difficult to review and approve projects very critically since all the delegates and observers know one other as friends.

There are differences between what is needed to fly on the Express Pallet or in pressurized modules. We need to formalize (not re-define) the requirements and constraints (such as room) before going any further with considering hardware proposals. We need to determine volume and power requirements, inside and outside. Things were made worse when we no longer had a Habitat module for locating hardware and antennas. (The Habitat module continues to be questionable as a location for installing our hardware – the Habitat module has been manifested and de-manifested from the ISS program several times.)

We need to learn of Habitat module possibilities for the Italian module. Also, Sergej needs to tell us the specific resource capabilities that we can utilize in the Service Module.

For Phase II hardware in the Service Module, we have Panel 426, which is 12 cm high, has equipment in it that must be removed if new equipment is sent up for installation. Or we can put equipment in front of the panel. The size is similar to the space used by the Ericcson and packet module. Carolynn may be able to learn who shares the space, and what is now stowed behind Panel 426. We were told we have the wall space in front of it, and can Velcro® something to it. Sergej needs to find out the volume — size and space.

Administrative Meeting

National Identifier (Call Sign) International Regulations: Ken Pulfer

ITU meetings in Geneva are soon, and Ken will learn more about call sign regulations. Currently, we know call signs are international requirements for the identification of stations and for assigning responsibility in cases of interference. A call sign prefix is a national identifier. Prefixes are assigned to member states and to the United Nations.

ARISS is not either one of these, therefore, ARISS can't have an identifier. Only national administrations can work with the ITU. Ken is evaluating having each ISS participating administration assign a callsign for station use. Or we could not use call signs, and use *Alpha One*. This is similar to what is done by commercial television. Ken will work through the ITU to help it understand space considerations and, possibly to develop regulations in this new area.

Ken hopes to get the call sign VE0ISS for Canada.

Frequencies: Frank Bauer

ARISS uses 145.800 MHz as a downlink worldwide. Region 1 uses 145.200 MHz for the voice uplink. Region 2 and 3 use 144.490 MHz for the voice uplink. Packet uses 145.990 MHz as the worldwide uplink. The common worldwide downlink on

145.800 MHz for QSOs, schools and packet is very popular.

There are various problems in every country with the frequencies we use. But years of work and international collaboration were done to set these set up, and they are a major improvement from the earlier years. ARISS operations are much better than operations on previous human spaceflight missions.

School Contacts: Rosalie White

Our professional space agencies want schools to provide educational projects for students that revolve around a QSO. The agencies believe educational activities are important, rather than only having students take part in a stand-alone, 10-minute radio contact. The educational activities at the first ARISS school (in Chicago) resulted in a major impact on students, teachers and the community. Every student was involved; some tracked the space station, others created a timeline for a school day to compare to the crew's timeline, others designed a station for the year 2030.

The ARISS School Committee needs to begin organizing itself. The group needs monthly teleconference calls and to set up an e-mail system. The committee should devise rules to start selecting and prioritizing schools in a manner that is geographically fair and equal. The committee should devise rules to integrate new school applications with older US applications. We agreed last December to schedule the longer waiting U.S. schools from 1996-on; we have now had QSOs for 1/3 of these schools. We need representatives on the committee from all of our regions so we can devise and vote on selection rules.

Ken Pulfer: Canada has three school applications to consider.

Joerg Hahn: Europe has 12 school applications - ones from Finland, Italy, France, England, Scotland and Germany. Joerg is collecting these. In February, ARISS Europe accepted 7 of these applications.

A draft of Terms of Reference was developed by Europe for how the school committee should function. This is a starting place for the committee; we can discuss these draft Terms.

Europe needs a few good events to communicate to ESA how important the educational outreach is. A QSO at SpaceExpo would be a good beginning.

Will Marchant: The SpaceExpo is a very good opportunity, and we have attempted to set up this QSO. The Europeans need to complete their plans for it, and then we'll re-schedule such a QSO.

Russia has some school applications; the US has about 12 schools waiting from 1996-1999. It will take two years to complete schedules for school applications now held by all of our partner countries; schools must realize there will be a wait.

Rosalie White: We have a spreadsheet that the US delegates have set up to list schools that have already had school QSOs. This spreadsheet may work for schools waiting in the queue, and the committee can look at it.

QSL Card Discussion: Rosalie White and Will Marchant

We have addresses for hams living in Canada and in the US to send their QSL card requests to – we need addresses for other delegate countries that wish to handle QSLs. Manfred Lugert will find someone to be the European ops representative, Canada will get someone also, and Masanobu Tsuji will find someone for Japan.

The Ops Committee needs people in each region to handle their own school mentoring and preparation. Will, per ISS management, will interface with the ISS program to look at schools the ARISS School Committee has approved, and attempt to schedule them in the order of the list, depending on such things as orbital mechanics. There are currently schools that have been selected that are in a holding area, and will be told about 4 weeks in advance about a QSO schedule.

Offline, the Ops Committee will discuss regional policies they would like to follow for handling QSL card requests. Each region can have their own rules for handling QSLs. The ISS crew shouldn't be expected to keep a log, and will most likely not do this. Getting local ham clubs to handle the QSL cards will be harder, if a log must be crosschecked prior to sending cards. The honor system may be the best method of answering QSL cards.

The QSL card needs to have the addition of a box for checking off *SWL*. The RS call sign should be at the bottom left of the card. The schedule for the graphic development of the card should still allow time for these changes.

Future Meeting Plans: Frank Bauer

The next meeting will be in the October or November time frame, but the date and location need to be finalized. Canada has extended an invitation. Consideration must be made for logistics, visas for international travelers, and interpreters – holding meetings at space agencies eases these requirements. Ken will check on these things.

Hardware Meeting

At this point, Dave Larsen was teleconferenced into the meeting.

Hardware Status: Lou McFadin

The packet module will be replaced via a launch on 7A.1 because the RAM battery has died. The antenna systems are not complete until all the design changes have been integrated. The Russian and US sides can find a new EVA to deploy them. The transport frame designed by the Russian side is complete.

Here are some reminders for those developing hardware proposals. Developers must remember that they will need a large amount of money to fabricate and provide many identical operational flight units. Two units are needed at GCTC (for the hydrolab and for training), 2 for Energia, 1 for Johnson Space Center, 1 for Goddard engineering tests, one flight, 2 flight back-up units, and 1 for Orlando fabrication lab. Lou understood these needs after visiting GCTC. Hardware will have to be labeled with Russian nomenclature.

An extra unit might be needed if hardware is for a European module, and Europe does crew training. We need better communications with the ISS program office so they can tell us exactly how many units are needed.

If hardware proposed is for the remote Express Pallet, the number of units needed is lower – units aren't needed for crew training.

Digitalker Review by Delegates:Frank Bauer

The Digitalker was proposed for Phase 1 delivery. The delegates would like to see it operational in 1 - 1.5 years. For Sergej, the Digitalker is only an idea at this time; it must go through the Energia technical review. It also must be certified in the FGB, the Service Module, and launch in the MPLM in the Space Shuttle. It must be manifested, deployed and the crew must be trained. Then the installation must be scheduled.

The Digitalker must be changed to be compatiable with voltage and current requirements of the present radio system, or there is another possibility: it could go on the Express Pallet.

Having a speaker-microphone as part of the Digitalker would be highly desirable. We could then show NASA and RSA the benefit of having it onboard as part of our hardware package, since the crew would like a speaker-microphone capability. NASA and Energia must be convinced why we need new hardware.

We need to ensure that we tell the ISS program office that the Digitalker finishes up the Phase I hardware plan – it is not a new project. We get free transportation from NASA. SAREX gets a large amount of money from NASA for testing, certification and integration. ARISS needs to ensure that

NASA goodwill continues.

Thomas said it might be possible for the Digitalker to be used as a microphone/speaker in the transmit/receive modes. Unanimous approval was voted for the continuing development of the digitalker. The European team will review the design to include functionality as a speaker/microphone.

A motion was made by Gaston, seconded by Ken, and the ARISS group voted unanimously to support a Digitalker proposal written as follows. The ARISS group will renew its request for permission to install a Digitalker onboard the ISS. The equipment is to be qualified for installation in the FGB, SM and US modules. It will be qualified for service as a Digitalker, with the design being reviewed to include functionality as a speaker-microphone. This equipment interfaces with existing Phase I interior ISS ham hardware only. The hardware committee will utilize requirements, definitions, and design and certification processes as discussed at the ESA meeting, today, May 2001.

Service Module Capabilities: Sergej Samburov

Before Sergej began speaking, Carolynn presented him with a signed Expedition 1 crew photo in appreciation of his hard work and of the Russian efforts. The ARISS group applauded Sergej to show their thanks.

The SM has four cables and one power connection. Current consumption is limited. In principle, we could have radios attached to each of the four antenna systems. But most importantly, the SM has limited room for radios, and second, we wish to keep the interaction with the crew as simple as possible.

Sergej is responsible for the SM radio system. The current ISS ham radio system is considered by Sergej as temporary; Sergej suggests one MMI (Man-Machine-Interface) with a display and keyboard that can be placed on the wall of Panel 426. A possibility is using a radio with a detachable front faceplate. This would allow a convenient operational location. We might be able to use room behind the panel for the main part of the radio. The area in front of Panel 426 is limited; if we wanted to do more than what Sergej suggests, we would have to negotiate for more space.

Specifications of power were 10 amps, 28 volts. Because there are problems with the solar panels, only 2 amps are available, currently. There is no ventilation in this place. We will have to find a way to cool it.

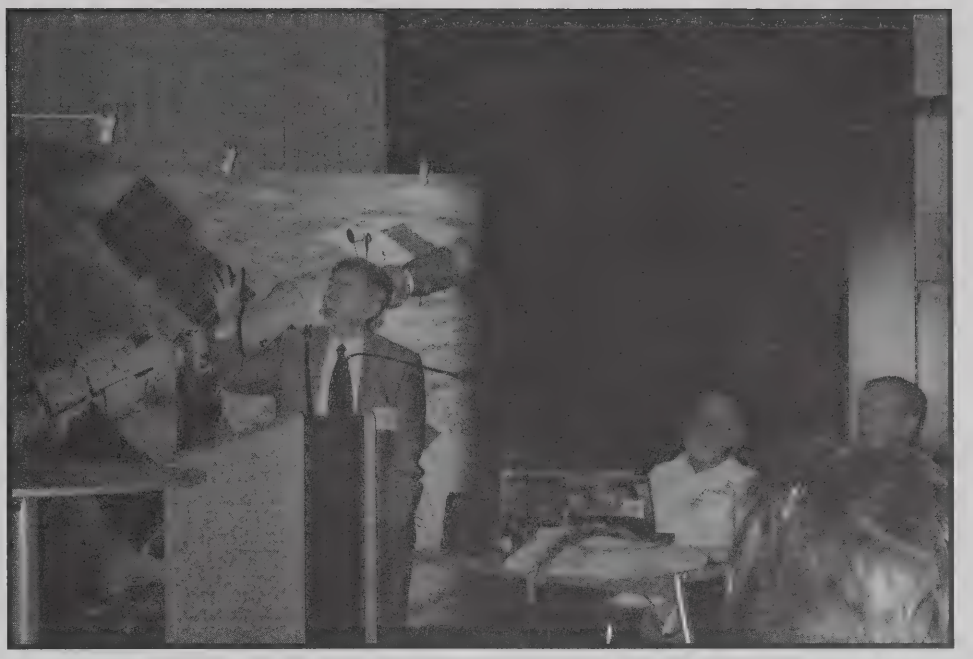
Requirements: Frank Bauer

Our first questions should be, "Who are our customers?" They are Amateur Radio operators, the ISS crew, educational outreach and space agencies. We need to educate the ISS crews as to who the customers are. We also need to define the objectives of ARISS. The discussion resulted in the following objectives and statements:

ARISS Objectives on the International Space Station (based on mission objectives)

ARISS will:

- SERVE as an educational outreach tool,
- BE an outreach to the amateur radio com munity and the general public,
- ALLOW a method for crews to maintain contact with family and friends while on orbit (to improve crew psychological factors),
- PROVIDE an experimental communications test bed,
- OFFER a back up communications link for emergencies, and
- PROVIDE public information to the grassroots public.



Based on these top-level objectives, a series of derived requirements have been developed:

- Eight minute contact with well equipped ground station
- Computer to computer radio links
- Thirty-second contact with a minimal ground station
- Autonomous beaconing of status in digital form
- Still picture transmit & amp; receive
- Video transmit & amp; receive
- Support continuous contacts (for at least thirty minutes)
- Support multiple concurrent operations: Space-to-space as well as space-to-ground operations

The team spent a great deal of time defining some of the initial requirements for the Phase 2 hardware. This exercise illustrated the fact that an assumption by one person is not necessarily what another person (from another country) is thinking. This emphasized the need for the team to formally define the requirements and capabilities of the Phase 2 system, as a team, before new hardware developments proceed. The entire team agreed to continue these discussions in future telecons and videocons.

Further requirements will have to be developed offline by committee. The Phase 2 requirements discussed and debated during the meeting are listed below. These will serve the amateur community for 3 to 5 years from now. The requirements must be correlated to the objectives and derived objectives. All unapproved proposals will go to the Hardware Committee to review.

Phase 2 Requirements

- Maintain current level of service (2-meter, 70cm FM voice, 1200 baud AFSK packet, SSTV and DigiTalker)
- Crossband operations 2m/70cm –Repeater operation (uplink)
- 10 meter multimode operations
- High speed packet (9.6 - 56.6 simplex, FSK)
- Digipeat packet 9.6k on 2m / 70 cm –PMS
- Time Frame Phase 2? (2004 Q2)

All unapproved proposals will go to the Hardware Committee to review. Certification of projects won't begin until the ARISS group is assured all requirements can be met. The Digitalker might fly on a Progress flight. The US has taken responsibility for certification of US projects and the Digitalker. Energia covers Russian projects. We will all work together to complete certification of other region's projects.

Proposals

The ARISS group listened to more details about the SpaceCam2 proposal and the Compressed Digital Amateur Radio TV (CDATV) presented by Miles.

All unapproved proposals will go to the Hardware Committee to review. Proposals are available on the WWW page.

During the final discussion/meeting closing portion of the meeting, all expressed their excitement of working together. It was truly a learning experience for all, and Roy Neal's description of the ARISS team going through adolescence is a very accurate representation of our current state.

The meeting was adjourned.

Respectfully submitted,

Rosalie White, K1STO■

Field Ops Update: 2001 Dayton Hamvention Highlights

Barry A. Baines, WD4ASW

AMSAT enjoyed another outstanding weekend at the Dayton Hamvention. Thanks to the efforts of our cadre of dedicated volunteers who manned the AMSAT booth, made Forum presentations, and assisted with setup and takedown of our exhibit, AMSAT had a very strong presence at this year's Hamvention. Highlights included:

• For the second year in a row, AMSAT offered a 'membership incentive' for those individuals who joined or renewed their AMSAT membership at the Dayton Hamvention. This year's grand prize consisted of a SSB UEK-3000 2.4 GHz downconverter and Phillips-Tech SPG-24 antenna that was combined with Down East Microwave's donation of a 1268-144TX transmit Converter which features 15+ watts output from 0.1 to 10w input on two meters and 2324YRM (24 elements/6 foot boom). The combination of these units created an AO-40 class station (Mode-L uplink and Mode-S downlink). Each individual who paid for a new or renewing AMSAT membership was eligible for the prize. Over 230 memberships were handled at Dayton this year.

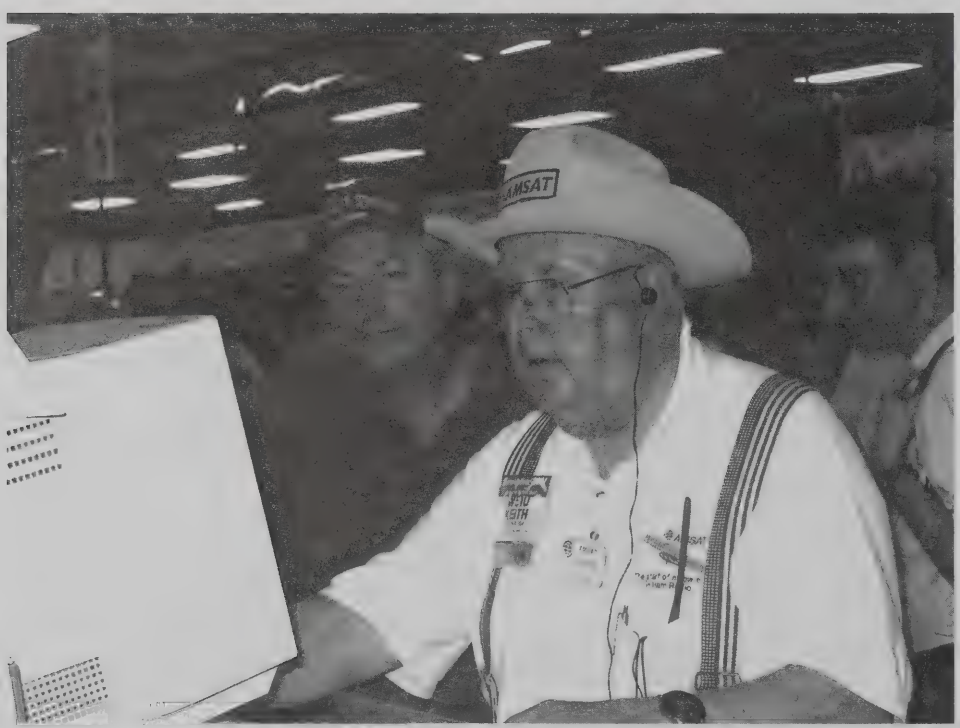
• Despite the drop in attendance versus year 2000, total AMSAT gross revenue nearly equaled last year's record level of revenue.

• The AMSAT Forum on Saturday morning was packed with nearly 300 attendees. The major areas covered were Amateur Radio on the International Space Station (ARISS) and AO-40.

• AMSAT's library of newly updated publications was very popular. Gould Smith, WA4SXM's *Analog Satellites Operating Guide* now includes information on AO-40 as well as updated information on ISS and other satellites. The book was sold out at Dayton. Gould also provided an updated *Digital Satellite Guide*. Ed Krome, K9EK released his eagerly awaited update to *Mode S:The Book* (2001 update) which has new chapters on S-band on AO-40. Mike Seguin, N1JEZ provided an updated *Working the Easy Sats* as well as assisting Bill Tynan, W3XO and Barry Baines, WD4ASW in providing an updated *Amateur Satellite Frequency Guide*.

• For the first time, AMSAT offered back issues of *The AMSAT Journal* on CD-ROM.

• AMSAT's theme at Dayton this year emphasized Amateur Radio on the International Space Station. The stage was set at the AMSAT booth with a large banner at the booth that proclaimed *AMSAT: Pioneering the future of Amateur Radio on the ISS* as well as a T-shirt and golf shirts available with this slogan.



AMSAT Vice President of Operations Keith Pugh, W5IU (r) provides a potential satellite user with a demonstration of NOVA tracking software.

• For the first time, AMSAT had available at the Hamvention booth Mode-S equipment. SSB Electronics agreed to allow AMSAT to have their UEK-3000 downconverer available at the booth with AMSAT taking backorders once the initial stock was depleted. AMSAT also had the Phillips-Tech SPG-24 2.4 GHz antenna available as well. All 19 SPG-24 antennas were claimed by Saturday morning.

• As in past years, the Arrow Antenna was available at the AMSAT booth as well. These antennas continue to be very popular with 27 units sold during Hamvention which wiped out the available supply. AO-27 and UO-14 satellite demonstrations using an Arrow Antenna with HT were conducted by Jerry Schmitt, KK5YY through out the weekend.

• The AMSAT Friday evening dinner at the Amber Rose Restaurant was well attended. For the first time, the dinner included an after dinner program presentation. Jerry Schmitt, KK5YY provided an entertaining and informative look at his participation in the Alaska 2001 Iditarod and using the amateur satellites from the interior of Alaska.

• During the Saturday evening Hamvention banquet, Frank Bauer, KA3HDO (AMSAT VP-Human Space Flight) received the Hamvention Special Achievement Award for his work on Amateur Radio on the International Space Station (see page 18).

For the second year in a row, the Dayton Hamvention was celebrating a milestone. In 2000 the Hamvention served for the first time as the ARRL National Convention. This year, Hamvention itself was celebrating its 50th show. The Hamvention started in 1952 at a hotel in downtown Dayton and has since grown to become the world's largest Amateur Radio gathering.

AMSAT is blessed to have a cadre of individuals who handle the preparations for Hamvention, deal with booth setup, and work the variety of logistical issues that are part of Hamvention. Arrangements began with obtaining a block of hotel rooms at the Homewood Suites under AMSAT's control that Martha Saragovitz coordinated. Dayton Team Leader Barry Baines, WD4ASW coordinated booth arrangements with the Hamvention Committee and phone line requirements with Hara Arena's supplier. Keith Baker, KB1SF and Robin Haighton, VE3FRH worked with the Hamvention Forum Committee on Forum time and location. Based

upon the strong interest shown at the 2000 Hamvention AMSAT Forum (a packed meeting room), AMSAT was offered a larger room for this year's Forum on Saturday morning. Given the high demand for Forums (For the first time in several years, all forums were held at Hara Arena), the fact that AMSAT received 'prime' location and time certainly highlights the interest in our activities.

Efforts then began in earnest to provide updated materials at Dayton and to coordinate the myriad of AMSAT activities at Dayton. Ed Collins, N8NUY worked with the Amber Rose Restaurant to finalize arrangements for the Friday evening dinner and publicized the dinner on amsat-bb. Authors Ed Krome, K9EK and Gould Smith, WA4SXM along with Mike Seguin, N1JEZ were contacted to ask about updating their publications in time for Dayton. Bill Tynan, W3XO with the assistance of Mike Seguin, N1JEZ and Barry Baines, WD4ASW updated AMSAT's *Amateur Satellite Frequency Chart*. At a lunch gathering on 01 April 2001 in Greenbelt. MD attended by Robin (VE3FRH), Martha, Barry (WD4ASW), Frank (KA3HDO), and Will (KC6ROL) just prior to the AMSAT-DC meeting at Goddard Space Flight Center, agreement was reached on the design of a new golf shirt and T-shirt for Dayton based upon a design created by Frank and Will.

As materials needed for Dayton were collected, boxes of our inventory were shipped to Dayton. AMSAT is indeed fortunate that Keith Baker, KB1SF lives in the Dayton area, as he provides an invaluable service by receiving these materials and placing them in a storage locker along with all of the other AMSAT booth materials. Keith also arranged for rental of a van to transport our booth equipment along with the books, trinkets, etc. that we offer every year.

The first wave of volunteers met for breakfast at the Homewood Suites on Thursday, 17 May. Keith, Robin, and Barry went to obtain the rental van and returned to the hotel. They were joined by a group of volunteers that consisted of Ken Chaffee, WA1QXR, Jerry Ervine, KC5YRE, and Ed Collins, N8NUY who proceeded to the storage locker to collect the booth equipment, boxes of stuff shipped to Dayton, and support materials and place it in the van. The group then proceeded to Hara Arena.

Setup at our usual booth location (445-448) went smoothly on Thursday as additional volunteers (such as Jerry Schmitt, KK5YY) arrived to assist with the process. Steve Culp, K8QKU and Larry Koziel, K8MU arrived on the scene with Martha Saragovitz and John Shew, N4QQ as they had stopped at the airport to pick them up and bring them to Hara Arena. Rick Hambly, W2GPS and Tom Clark, W3IWI arrived at Hara on Thursday afternoon with the Microsat engineering model in hand for display at the AMSAT booth. Keith Pugh, W5IU drove in from Ft. Worth and set up his computer for demonstrating Nova, Instant Track, and Quiktrak.

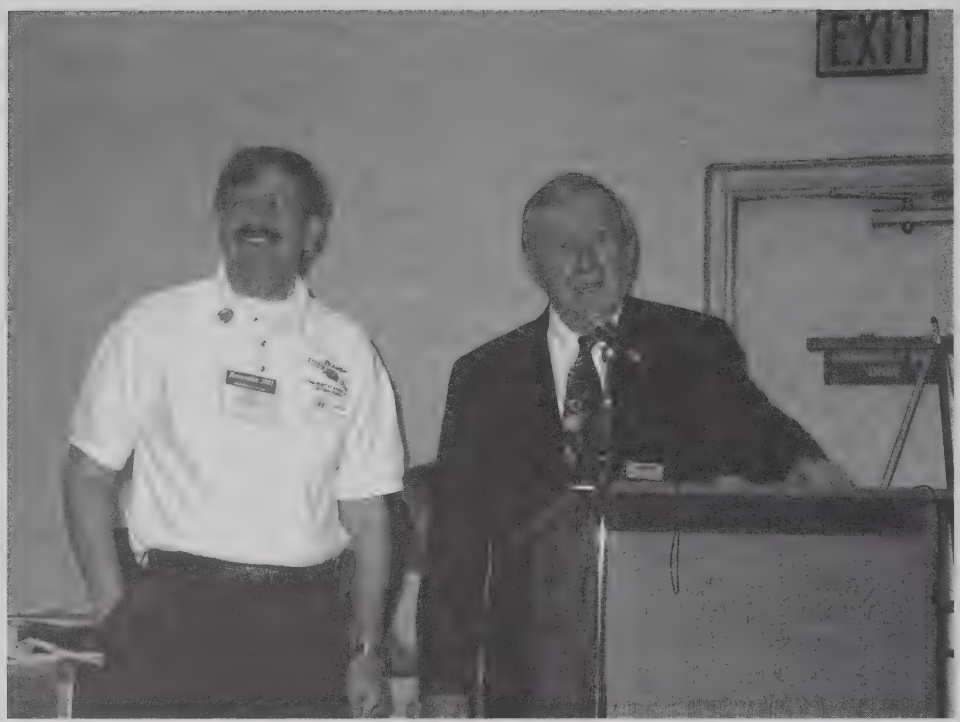
The opening of Hamvention on Friday at 0900 began a three-day marathon of booth activities. Martha Saragovitz and Barry Baines coordinated the myriad of charge card activities as well as handled membership questions. For the first time in many years, Bob Carpenter, W3OTC was not at Hamvention, so he sent to Barry the AMSAT membership data files to run on his laptop as well as be able to provide WiSP registrations. With Friday being a very rainy day, aisle congestion was much greater than normal as attendees stayed indoors to avoid the inclement weather. Fortunately, the weather was sunny on Saturday and Sunday.

AMSAT Thanks the Following Individuals for Their Time/Support Assisting AMSAT at the 2001 Dayton Hamvention.

Barry Baines, WD4ASW Jacksonville, FL
Keith Baker, KB1SF Xenia, OH
Frank Bauer, KA3HDO Silver Spring, MD
Ken Chaffee, WA1QXR Ashaway, RI
Tom Clark, W3IWI Clarksville, MD
Ed Collins, N8NUY Dayton, OH
Steve Coy, K8UD Fairborn, OH
Terry Douds, N8KI Lancaster, OH
Jerry Ervine, K5YRE Hidalgo, TX
Dave Filmer, W9DF West Lafayette, IN
James French, W8ISS Lincoln Park, MI
Bdale Garbee, KB0G Black Forest, CO
Steve Gocala, KB8VAO Youngstown, OH
Robin Haighton, VE3FRH Burlington, ON
Rick Hambly, W2GPS Severna Park, MD
Paul Hise, AA9GY Jeffersonville, IN
Dee Interdonato, NB2F Lodi, NJ
Denny Jakubisin, WB8K North Royalton, OH
Mark Johns, K0MDJ Cedar Falls, IA
Roger Johnson, WB0GAI Greeley, CO
Jim Keeth, AF9A Indianapolis, IN
Frank Kostelac, N7ZEV Las Vegas, NV
Howard Long, G6LVB London, England, UK
Jerry Malin, N2HV Matthews, NC
Will Marchant, KC6ROL Marshall, VA
Louie Mamakos, WA3YMH Laurel, MD
Ed Manuel, N5EM Houston, TX
Joe Mayfield, KA0YOS Watertown, SD
Roy Neal, K6DUE High Point, NC
Jon Ogden, NA9D Algonquin, IL
Eddie Pettis, N5JGK Vicksburg, MS
Mal Preston, NP2L Cruz Bay, VI
Keith Pugh, W5IU Ft. Worth, TX
Bill Reynolds, K8DNE Rowlett, TX
Martha Saragovitz Silver Spring, MD
Jerry Schmitt, KK5YY Los Alamos, NM
John Shew, N4QQ Silver Spring. MD
Gould Smith, WA4SXM Knoxville, TN
Carl Starnes, W4EAT Stanfield, NC

Demand for AMSAT materials was very high. The AMSAT booth was the only location at Hamvention where one could obtain NOVA-32. Both QuikTrak and Instant Trak were also in high demand. For the first time ever, *The AMSAT Journal* on CD-ROM was available, with one volume for 1994-1996 and the other volume covered 1997-1999.

One of the new approaches taken at Hamvention this year was to have Mode-S equipment available at the AMSAT booth. Discussions with Gerry Rodski, K3MKZ resulted in an arrangement whereby AMSAT would offer the UEK-3000 at the AMSAT booth with a portion of the funds for each downconverter going to the AMSAT coffers. SSB allowed AMSAT to take back orders once our supply of downconverters were no longer available. This arrangement allowed AMSAT to receive a portion of the proceeds for each unit backordered at Hamvention, as the SSB booth did not have the UEK-3000 in stock due to SSB giving AMSAT their available supply. To complement the downconverter, Barry Baines ordered 20 Phillips-Tech SPG-24 *barbeque grill* antennas to be shipped to Dayton from California. This was a one-time arrangement that would allow AMSAT members to benefit from a *group buy* and provide for easy pick-up. Interest in AO-40 was very high as the available downconverters were gone by Friday afternoon and the SPG-24 antennas were gone by Saturday. Gould



Frank Bauer, KA3HDO (l) and Roy Neal, K6DUE (r) presenting ARISS operations to Dayton Hamvention participants.

Smith's new *Analog Satellite Operating Guide* now includes detailed information on AO-40 including a discussion of AO-40 telemetry and how to set up P3T. Gould's book soldout by Sunday.

Once again AMSAT offered the Arrow Antenna at Hamvention. Somewhat to our surprise, the 24 units originally available were gone by Saturday afternoon, so we obtained the remaining Arrow Antennas from Alan Lowe and made available three more. It is clear that AO-27 and UO-14 continue to be popular satellites. Jerry Schmitt, KK5YY provided FM satellite demonstrations on Friday and Saturday which helped to increase interest.

Another change from past years is that AMSAT President Robin Haighton, VE3FRH scheduled 'office hours' at the AMSAT booth so that members would have an opportunity to discuss whatever happened to be on their minds about our organization. By providing specific times that Robin would be available (publicized in advance via amsat-bb and signs at the booth), this approach

Frank Bauer, KA3HDO Receives Dayton Hamvention Special Achievement Award

Frank Bauer, KA3HDO received a Special Achievement award for his efforts in developing and promoting SAREX and ARISS within the Amateur Radio community. As AMSAT Vice President of Human Space Flight, Bauer provided the following remarks upon receipt of his award:

I would like to thank everyone, especially the Dayton Hamvention committee for this very prestigious recognition. I am both honored and humbled to accept this award.

Radio amateurs have a rich pioneering spirit. This past year the pioneering spirit and drive of the Amateur Radio on the International Space Station (ARISS) team have blazed a new trail in space—permanence on the ISS. To achieve this permanence, the ARISS team had to overcome tremendous technical and political challenges. The cultural differences of the 9-nation team were immense. From a technical perspective, we had the challenges of being the first—the first payload that would fly on ISS, the first US hardware to fly in the Russian modules—no one in NASA or on the Russian side really knew how we should be qualified. Less than three weeks before launch, we still weren't qualified. But we persevered; we made it happen.

In my early youth, my grandmother instilled in me qualities that I now see were essential for the complexities and difficulties of ARISS project to succeed. These qualities include an intense interest in the space program, an insatiable desire to learn new things, an optimistic point of view, a "never give up" attitude and a visionary spirit. Over the past 25 years, I have been involved in many extremely challenging space flight initiatives at NASA, including the complex repair of the Hubble Space Telescope. However, the past five years as the volunteer lead for ARISS were, in reality the most challenging and most rewarding.

You might ask—why does my team pour their hearts and souls into this program?

There are three main reasons:

1) Each time we do a school contact, we see an awe inspiring event unfold in front of our eyes—we give the students, the parents and the whole community an opportunity they will never forget in their lifetime.

2) The profound impact we make on the astronauts and cosmonauts when they talk to their families. For example, during Dennis Tito's visit to ISS, I had the opportunity to listen to some of the most inspiring and emotionally intense dialog between Dennis and his sons

3) The excitement we generate when we bring the space program literally into the ham shack of Amateur Radio operators worldwide.

I am not a loner in this endeavor. Thus, I feel it is appropriate to recognize those that have made this award and the success of ARISS possible:

To Roy Neal, K6DUE, whom I am deeply indebted. You kept me going during the rough times and you have made this year a tremendous positive for ARISS, for my family and for me. To Rosalie White, K1STO, for all her efforts as my counterpart at the ARRL. To AMSAT presidents Bill Tynan, W3XO, Keith Baker, KB1SF and Robin Haighton, VE3FRH. To my ARISS-US team, especially Will Marchant, KC6ROL—my ops manager and right-hand man, to Lou McFadin, W5DID, my Hardware Manager, and Carolynn Conley, KC5SJO, our NASA rep. Their tireless efforts behind the scenes make an extremely challenging endeavor look easy. They put in thousands of hours each year because they believe in what we are doing in space. They believe in our youth and they believe in Amateur Radio. To the ARISS international team—together, they made 2001 a space odyssey for the Amateur Radio community. And finally to my family, my wife Janet, and my children Steven, Brad, and Michelle—for being understanding and having the patience to put up with my hobby and the intensity that I have put in this program. ■

was designed to make the President more accessible to the membership. When Robin wasn't speaking with a member, he contributed his time to manning the booth and responding to queries from those who needed an item or handling their membership needs.

One of the joys of Hamvention is the opportunity to see old friends and to meet new ones. The annual AMSAT Friday night dinner took place once again at the Amber Rose Restaurant in Old North Dayton. Ed Collins, N8NUY who took advance reservations and maintained the 'head count' for the restaurant, coordinated the affair. Ed also was available at the AMSAT booth on Friday to take additional reservations and provide directions on how to get to the Amber Rose. Over 75 people attended the dinner. As usual, the Amber Rose did a fine job of providing a well-prepared meal that was moderately priced. For the first time, we had an after dinner program which turned out to be very successful. Jerry Schmitt, KK5YY of Los Alamos, NM spent a portion of his vacation time serving as a volunteer for the famous Alaska Iditarod dogsled race. Jerry had a very entertaining and informative presentation on the race and using the Amateur Radio satellites in the interior of Alaska. The consensus of the group was that next year's dinner will also be at the Amber Rose and we will hopefully have another after dinner program.

The intensity of Hamvention on Saturday was high immediately after opening as the AMSAT Forum was scheduled from 0830-1000. Almost immediately after the commercial exhibits opened at 0800, a large crowd gathered in Forum Room 1. The AMSAT Forum covered three areas: *Amateur Radio on the International Space Station*, *AO-40 Status*, and *AO-40 Ground Station Requirements*. Roy Neal, K6DUE who serves as Chairman of the ARISS Working Group and Frank Bauer, KA3HDO, AMSAT's VP-Human Space Flight, led the ARISS portion of the Forum which discussed not only the current status of ARISS and future plans, but attempted to include some 'special guests.' These guests included an attempted 2-way QSO with the ISS Expedition 2 astronauts via an ARISS ground station in Australia (Tony Hutchison, VK5ZAI). While Tony could be heard via the Forum PA system, the attempted contact was unsuccessful. Next, Roy Neal had an interview with astronaut Janice Voss, KC5BTX in Houston. Technical problems diminished the impact of the interview somewhat, but attendees were able hear Roy's questions and the answers from Janice. The last 'guest' was Dennis Tito, KG6FX who had just returned to the US following his time as a 'space tourist' on the International Space Station. Again, technical problems marred the interview somewhat, but everyone heard the enthusiasm in his voice concerning his trip to ISS and the importance of Amateur Radio in enhancing the experience and being able to share his thoughts with his family from orbit.

Following the ARISS portion of the Forum, Robin Haighton, VE3FRH provided a status report on AO-40 and the success that amateurs were enjoying using the VHF/L-band uplinks and Mode-S downlink. Bdale Garbee, KB0G then presented an outstanding overview of AO-40 ground station requirements. Bdale included a 'show and tell' in his presentation by having various devices passed around the Forum as he spoke about downconverters and pre-amps. His presentation also included a discussion of the equipment used by the RUDAK team (led by Jim White, WD0E) to send/receive information with AO-40 as well as photos of various Mode-S devices. Bdale's talk was very

AMSAT Top Gun! **On Thursday eveing during the *lull before the (Dayton Hamvention) storm*, Kenwood Communications Corporation hosted a reception during which Barry Baines, WD4ASW (Board of Director and AMSAT VP-Field Operations) received their *Top Gun Award.* Barry was recognized for his efforts in building interest in amateur satellite communications at various hamfests and for promoting Amateur Radio. The reception provides an opportunity for Kenwood to thank their distributors/retailers for their support as well as serves as a vehicle for publicizing Amateur Radio developments and give recognition to the accomplishments of organizations. At this year's reception, AMSAT President Robin Haighton, VE3FRH gave an update on the status of AO-40. Ron Parise, WA4SIR gave an overview of current status of Amateur Radio on the International Space Station and future plans. It was at this reception that Kenwood announced their new tri-band hand-held (TH-F6A) with wide-band receive including HF. (Photo via Paul Middleton, Kenwood Corp.)**

successful and probably contributed to the heavy demand for copies of Ed Krome's just updated *Mode S-The Book* which was delivered to the AMSAT booth on Saturday morning from the printer just prior to the Forum. AMSAT thanks the ARISS team and Bdale Garbee for providing a very interesting and informative Forum.

The annual Hamvention Banquet was held Saturday evening at the Nutter Center. Roy Neal, K6DUE was one of the primary speakers at the Banquet. Frank Bauer, KA3HDO was presented the Special Achievement Award for his contributions to SAREX and ARISS. Frank's efforts to bring Amateur Radio to manned space flight have resulted in a unique working relationship between NASA and the Amateur Radio community. Whereas having Amateur Radio on the space shuttle was done on an experimental basis, we now see Amateur Radio is an integral part of the International Space Station.

On Sunday, Hamvention was open from 0800-1300. At 1200, AMSAT had its drawing for the Membership Incentive Prize which consisted of Mode-L and Mode-S equipment for an AO-40 ground station. Bob Halley, K8YMI of Terrace Park, OH, won the main prize. AMSAT also gave away an unmodified Drake 2880 Mode-S downconverter that had been donated by Mark Fossum, N0NSV. Melvin Vye, W8MV of Akron, OH was the lucky winner. As neither Bob nor Melvin were at the Hamvention on Sunday, the equipment was shipped from Hamvention to their respective homes. AMSAT thanks Downeast Microwave for their generous donation of transverter and antenna as well expresses our appreciation to SSB Electonic, USA for their support.

After the commercial exhibit area was closed at 1300 and while attendees sat in Hara Arena to see if they won any prizes, our volunteers proceeded to dismantle the AMSAT booth, pack boxes for shipment back to Silver Spring and load the van. In about 90 minutes the entire process was completed, including delivery of about 20 boxes to the Mail Box etc. folks who were in the North Hall. By the time that prizes were drawn, the van was ready to proceed back to the storage locker. The same team that loaded the van on Thursday unloaded our materials back at the locker. The van was returned to Budget on Monday and another Hamvention was history.

Several announcements were made during Hamvention that are of interest to AMSAT members. First, *CQ Magazine* announced the establishment of an "Amateur Radio Hall of Fame" that is predicated upon either significant achievement in the honoree's professional field or impact upon Amateur Radio. The list of 50 initial inductees was printed in the May/June 2001 issue of *The AMSAT Journal*. Second, AMSAT President Robin Haighton, VE3FRH announced the establishment of the *President's Club* which is a sustaining donor program recognizing those individuals who contribute at the 'Silver Level' ($50/month) or 'Gold Level' ($100/month). As AMSAT proceeds with the next satellite project, this is one approach towards attracting the funds needed to support our activities.

Dayton Hamvention continues to be an exciting place for Amateur Radio. AMSAT certainly enhanced the overall scope of Hamvention with an outstanding booth display, a high degree of interest in our Forum, and the opportunity to socialize and exchange ideas. Our success is due primarily to the score of dedicated volunteers who handled setup and takedown, man the booth during Hamvention, give presentations at Forums and elsewhere, and represent AMSAT so ably during Hamvention. Thanks also to AMSAT Office Manager Martha Saragovitz who has a keen eye for detail, a willingness to keep the team 'on track' and the ability to deal with the myriad of - Hamvention challenges with grace. As always, Dayton Hamvention was both physically demanding and a fun filled weekend coupled with a great senses of teamwork and cooperation that resulted in another success for AMSAT. Thanks!■

AMSAT HF/VHF/UHF Nets

Compiled by Andy Reynolds, WD9IYT

HF Nets

Name	Day	Time	Frequency (MHz)		Net Control
East Coast AMSAT Net	Tuesday	2100 Eastern	3.840 (+/- QRM)		Al Tribble, W3STW
Mid-America AMSAT Net	Tuesday	2100 Central	3.840 (+/- QRM)		Keith Pugh, W5IU & Bill Tynan, W3XO
West Coasat AMSAT Net	Tuesday	2000 Pacific	3.840 (+/- QRM)		Net is not currently active
AMSAT-UK Net	Sunday	1015 Local	3.780 (+/- QRM)		Richard Limebear, G3RWL
AMSAT International Net	Sunday	1800 UTC	14.282 (+/- QRM)		Net warmup
AMSAT International Net	Sunday	1900 UTC	14.282 (+/- QRM)		Formal Net with Keith Pugh, W5IU; Larry Brown, W7LB; Wray Dudley, W8GQW

VHF/UHF Nets

Name	Day	Time	Frequency (MHz)	Net Control	Notes
Arizona AMSAT Net	Wednesday	2000 Local	146.880 (-)	Larry Brown, W7LB & Jim Weisenberger, AA7KC	This is a mountaintop repeater that provides good coverage of south and central Arizona including both Tucson and Phoenix.
Colorado AMSAT Net	Wednesday	2000 Local	147.225 (+)	Al Ventura, N0SVE & John Gubins, KB0VBZ	
Fort Worth/Dallas AMSAT Net	Wednesday	2100 Local	147.140 (110. PL)	Keith Pugh, W5IU; Doug Howard, KG5OA; Ray Hoad, WA5QGD; Richard Raitt, WA5VKS; Gary Persons, KD5DAY	
Houston AMSAT Net	Wednesday	0100 UTC	145.190(-) (123.0 tone)	Andy MacAllister, W5ACM and Bruce Paige, KK5DO	C-band TVRO net on Satcom 4 , transponder 24, 7.5 MHz audio. Also available via Real Audio at http://www.amsatnet.com/
Los Angeles AMSAT Net	Thursday	1900 Local	145320 (- & 114.8 PL)	Ronalee Fitch, N6SHI and Stanley Johnson, W6EKK	
Southeast Michigan AMSAT Net	Sunday	2000 Local	145.330, 442.800, 1282.05	James French, KD4DLA	Featured topics on the net include but not limited to: AMSAT News Service Bulletins, ARRL, and NEWSLINE space related Audio News clips NASA Science.com messages, latest Spaceweather.com updates and news NEAR-Shoemaker, Pioneer, Voyager, Space Shuttle, and International Space Station Status reports, MIREX Bulletins, MABEL-1 Balloon updates along with any other balloon launch news, Updates on the status of local Fast-Scan ATV and Audio rebroadcasts of NASA Select, Plus trying to answer any and all questions about AMSAT and Amateur Satellites
Southwest Ohio AMSAT Net	Tuesday	2000 Local	145.110 (-)	Frank McGrath, N8XPC	There are five operators who take turns as NCS, with WB8IFM usually reading bulletins (and acting an alternate NCS) plus handling Q & A sessions.

Satellites—What's Exciting, Today and Tomorrow!

Do you have a friend who is interested in learning about how to operate through the satellites? Then do them a favor! Here's the perfect thing — encourage them to participate in this fast-paced workshop! Just for you and your friends...learn what's new in the exciting Amateur Radio satellite world! Sign up for a fast-moving 5-hour workshop — all you need to get *on the birds*, the 16 ham radio satellites now in orbit, including digital satellites that are bulletin boards, FM satellites you can work with an HT and hand-held antenna, low earth orbit SSB/CW Easy Sats on 2, 10 and 15 meters, high altitude DX satellites such as AO-40 and AO-10, and Amateur Radio on the International Space Station. You'll learn each satellite's equipment requirements (plus antennas, rotators, cable), how to be operational on AO-40, tracking satellites with your pc, operating protocol for each satellite, and where to get information from AMSAT, ARRL and the WWW.

WHAT: Workshop...Satellites—What's Exciting, Today & Tomorrow!

WHO: Instructors Steve Bible, N7HPR and Larry Brown, W7LB

WHEN: Friday, September 7, 2001, 1300 hrs (after lunch) to 1800 hrs. Arrive early for handouts!

WHERE: ARRL Southwestern Division Convention, Riverside, CA.

HOW: Space is limited. To register, call/write Linda Mullally, telephone: 860-594-0292 at ARRL, 225 Main, Newington, CT 06111 before 01SEP01.

Price: $25 for ARRL members, $35 for non-members. You will receive free lecture materials and 5 hours of practical information. You can also purchase *ARRL Radio Amateur's Satellite Handbook*, to read beforehand... $22 + $6 UPS shipping/handling). Sponsored by AMSAT & ARRL Field & Educational Services department. Those attending all day earn 0.5 Continuing Education Units.■

Report of the AMSAT Board of Director's Meeting
Held 24-25 February 2001 in Orlando, Florida

The meeting was convened by the Chairman, Bill Tynan, at 0805 EST on Saturday, 24 February 2001 at the Sheraton Four Points Hotel in Orlando, Florida.

Members of the Board in attendance were:

Barry Baines, WD4ASW
Keith Baker, KB1SF
Tom Clark, W3IWI
Dick Daniels, W4PUJ
Robin Haighton, VE3FRH
Andy MacAllister, W5ACM
Bill Tynan, W3XO

Others participating at various times included:

Ray Soifer, W2RS
Bill Burden, WB1BRE
Bdale Garbee, KB0G
Dick Jansson, WD4FAB
Lyle Johnson, WA7GXD
Phil Karn, KA9Q
Jan King, W3GEY
Lou McFadin, W5DID
Bruce Paige, KK5DO
Shep Shepard, AA7MH
Stan Wood, WA4NFY

I. Opening Remarks

After introductions were made, Chairman Tynan defined as the purpose of this meeting to make decisions with regard to AMSAT's future projects, and outline how such projects would be conducted and managed. He reminded the Board that, at their October 2000 meeting in Portland, Maine, the consensus was that we would continue building satellites, in addition to pursuing our other activities such as publishing and education. He noted that for the purposes of this meeting the term AMSAT refers specifically to the AMSAT-NA organization.

In order to accomplish this objective, he said, the Board invited a few of those who had been active in providing spacecraft designs and hardware in the past, as well as, new people who appeared to have the potential for future contributions, to present their concepts and suggestions for possible projects. He noted that some of the papers presented at the 2000 AMSAT Annual Meeting and Space Symposium, e.g. Dick Jansson's *So You Want to Build a Satellite*, Jeff Davis' *What's Next?* and *A Spectrum Wideband Transponder for the International Space Station* by Matt Ettus offered examples of some of the ideas that might be considered. He further noted the ideas proposed by Phil Karn and Lyle Johnson as also being worthy of consideration.

Tynan announced his intention as to how the meeting would be conducted, proposing that the various presenters be heard in full first, without criticism. The only interruptions permitted would be questions to promote full understanding of the proposal, without offering alternatives or reasons why it might be unacceptable. Following the presentations, ample time for criticism would be provided. He opined that, with any other approach, we might become bogged down and never achieve the goal of coming to an agreement on one or more new projects. He stated the intention that, by the close of the meeting, one or more projects would be chosen and initial funding provided to get them started. In addition, general agreements would be reached regarding management of the approved project or projects.

The Board members generally accepted the proposed approach, and the meeting began.

II. Strategic Planning Committee Report

Tynan noted that the previous week, the Strategic Planning Committee, had met in Silver Spring. He observed that, since their output form an important element in the Board's selection of any new project, he asked those present at that meeting for a report on its results.

Burden, Chairman of that group, reported that the meeting had been a great success, arriving at least a preliminary set of objectives. He said that a list of the participants and the conclusions reached have been documented in a report to be published in *The AMSAT Journal*. He noted that the deliberations were significantly aided by the participation of Martha's sister, Barbara Saragovitz, a Human Systems Engineer at the Federal Aviation Administration.

Baker echoed these sentiments and reviewed the relevant viewpoints developed. He then presented the Plan for Board approval. Noting that the Mission Statement had previously been approved at the 1989 Annual Meeting in San Diego, the Vision Statement, Strategic Goals and specific Strategic Objectives were then discussed. King asked if the items in the Value Statement were listed in order of priority. Clark recommended assigning a priority to each.

Baker next described the Vision Statement explaining that this presents an image of what AMSAT-NA will look like in 3-5 years. Taken together, the Mission Statement and the Vision Statement represent what the Strategic Plan hopes to achieve. He noted the Committee had extensively discussed what the term *continuous* meant in terms of future AMSAT satellite systems. Baker emphasized that this was not meant to imply any particular type of satellite, and added that the term *healthy* meant of significant robust design, i.e., long lived.

Clark asked about the apparent lack of mention of how to achieve the replenishment of and infusion of innovative, younger amateurs. Garbee replied that the Committee had declared that AMSAT should not try to solve the problems besetting Amateur Radio in general. It was concluded that ARRL is the proper organization to address this.

Daniels suggested putting more emphasis on the ground-based segment of the plans. Karn said that there were two aspects of this, one is to apply a systems level approach to the projects and stated that there was no point in developing a capability in a satellite if no one on the ground was capable of using it, and the second is to provide members opportunities to contribute on many levels. Recognizing that people who are merely using the satellites are also contributing, he suggested ways we can encourage them, e.g. by providing the right educational materials.

Tynan encouraged a partnership with TAPR, specifically to develop the ground segment. Baker agreed that the ground system is an important part of the system. Karn asked if innovation implied only how to use the higher frequencies, and noted that that type of expertise is already prevalent in the amateur community. But that, innovative modulation techniques and/or protocols etc, are less so. So, he concluded, we have the responsibility to provide appropriate informative materials, software and even hardware so hams can use such techniques.

The consensus of the Board was that the next step should be for the Committee to more precisely define the stated goals, and to come up with milestones, taking into account the volunteer nature of the organization, and its limited financial resources. Tynan noted the difficulty of accomplishing necessary tasks with all-volunteer labor, citing specifically, such jobs as obtaining components. This, generally must be done during working hours and is, therefore, difficult for volunteers who have regular jobs, to accomplish. He asked if the objective of using only volunteers, should preclude the participation of at least one paid full time person? The reply was that it was not the intention to place hard limits, but to generally prescribe that designs must be simple and capable of being accomplished by an organization such as ours. Baines agreed, saying that the consensus at the previous week's meeting was that we are a volunteer group and that the financial responsibility would be larger if we had to depend on contractors. Therefore, he concluded the emphasis was on keeping projects small enough so that we would not have depend on contractor labor, at least at the onset. Tynan opined that we should not preclude the use of some full time help. Baker replied that another objective was to allow people to participate at any level. Daniels said that experience has shown that a close-knit team is needed. That team must want to do things right, accept the relationship and operate within it or they'll lose interest.

Burden noted that the vision of the organization is not expected to change with the passage of time although these objectives could change or be revised anytime the organization thinks necessary, e.g., if a truly outstanding resource becomes available. Baker agreed, emphasizing that the Committee's document is not to be put on the shelf and left there – but continually reviewed. It was agreed that the Board ought to review the document yearly and update it as appropriate. Clark observed that the strategic goals regarding educational interfaces, mention university-based small satellite projects. He noted that we can also expect to have wider participation, e.g., from K through 12.

Soifer noted that amateur satellites can provide public service by providing facilities for emergency communications. He observed that this has been always been a noteworthy part of Amateur Radio in the USA, but that has not been the case in many other countries. However, he said, the situation is changing, mentioning the use of U0-14 during the recent earthquake relief effort in India. He said that the IARU will be trying to get the ITU to relax some of the international restrictions against third party traffic that has heretofore hindered public service communications by amateurs.

The final goal listed in the Report states "AMSAT-NA will acquire sufficient resources to support our vision." Baker observed the divergent nature of our membership with the technical innovators being a minority relative to the much larger group who are primarily interested in using equipment they already have, adding that it is this latter group that has provided the major funding for our projects. He expressed the belief that we must realize that it is necessary to broaden the base of the funding resources, if we are to continue pushing the state of the art. Tynan observed that this is one of the keys to the decisions that must be made at this meeting.

Burden mentioned the human resources required to support the satellite development goals.

Baker then asked the Board to consider agreeing in principle to the Strategic Goals. Tynan asked for a motion, thanking the members of the Strategic Planning Committee for their efforts and endorsing, in principle their output; and encouraging them to continue so that at the next Board meeting their recommendations can be formally accepted.

Baines asked to what extent can the Board endorse the plan at the present meeting with work still to be done on the document. Tynan replied that, in his view, the specific purpose of this meeting is to establish a proposed next project and advised against us getting involved with trying to *fix* the specific language contained in the Document. Haighton agreed with Tynan's call for a motion endorsing, in principle, the Committee's work, and said that, sometime in next month or so, he will call a teleconference to examine the details. Baker observed that, before choosing a project, we should establish that it is in conformance with the Strategic Plan. Haighton agreed saying that he was impressed that the Strategic Planning Committee had recognized the ideas that were already in motion and that the group had produced a number of good supportive ideas for oncoming projects. He opined that the document is good, possibly needing only a few minor changes. He maintained that, in its present form, it can serve as guidance in selecting a project.

Haighton then moved that "the Board approve, in principle, the Strategic Planning Committee's document and commend them for their work over the previous weekend." Clark seconded the motion that passed by unanimous vote.

Clark observed that none of the things in the Committee document were in conflict with the principles set forth by the original framers of AMSAT Bylaws.

III. Technical Presentations

Tynan asked Karn to lead off the technical presentations.

An Efficient Digital Modulation Mode for Voice and Data

Karn began by recognizing that satellite users constitute a very small percentage of Amateur Radio enthusiasts. This led him to ask why are there not more hams on the satellites?" to which he offered the suggestion that it is frequently due to the significant antenna requirements needed for a Phase 3 class station. He noted that restrictions in many residential areas, prevent the erection of suitable antenna systems. He also observed that cost and reliability of rotors and relays are also factors discouraging many. His solution is to reduce the ground station requirements to smaller and simpler antennas similar to those now used by the digital satellite TV services. To accomplice this with current analog systems, he said, would require making the spacecraft antennas larger, and/or having higher-powered on-board transmitters, or using low orbits to reduce the path loss. However, there are limits to the above, so he proposed adopting more efficient digital modulation techniques. Such a system, he said, would include telephone quality voice as well as data. To accomplish this, he proposed the use of power-efficient modulation techniques incorporating Forward Error Correction (FEC); which, he said, provides a 7 dB or more improvement in link margin with the same power. He envisioned the use of high rate QPSK and Time Domain Multiple Access (TDMA) to provide multi-user capability.

Specifically, Karn proposed building a Microsat-class L/S band LEO satellite with uprated solar panels. It would be designed as simply as possible with the majority of complex circuitry delegated to ground stations. As a baseline, he said, bandwidth requirements would be 150 to 200 kHz to accommodate approximately 13 simultaneous users at bit rates of 6 kbs. He emphasized that these parameters are applicable to the LEO system he is proposing. If a higher orbit satellite is desired, they would change. He noted that link margins are more favorable at lower altitudes resulting in improved data rates and also that the lower propagation delays are beneficial to the performance of multiple access schemes such as TDMA.

He went on to explain that the space and ground portions must be designed as a system. He noted that, in the past, AMSAT has traditionally focused on building only the space segment. In the system he is now proposing, the user becomes a key part, and must have suitable compatible equipment. The development and distribution of such suitable compatible equipment would represent a major portion of this proposed project. He contended that this is not an insurmountable obstacle, citing the example of the TAPR TNCs. Because of the unique nature of Amateur Radio satellites, Karn noted, where the spacecraft owner cannot charge for accessing it, one should make the spacecraft as inexpensive as possible and put more complexity on the ground. Although this might increase the total system cost, he noted, that cost would be spread out over many users. "We've learned," he said, "how difficult it is to raise money for a complex spacecraft, and thus it might be easier to get hams to invest in their own station equipment rather than contribute so much to the building an expensive spacecraft."

Karn said that he would propose the use of microwave frequencies to reduce the size of the antennas, important for many living with antenna restrictions. This, he contended would outweigh the disadvantage of extra cost for the ground station equipment. He noted an upsurge of interest by hams in 2.4 GHz equipment and that the cost of such equipment is rapidly coming down. Therefore, soon it might not be more expensive than equipment for lower frequencies.

Karn then announced he had made a significant financial contribution to AMSAT, aimed at supporting the development of such a system. He stressed that this development should be subject to only a few conditions. First, everything in the project should be open sourced for others to work on, improve and learn from. He said that he feels strongly about this because he believes it vital due to the educational and self-training aspect of Amateur Radio. This, he said, may, in the future, be the hobby's sole justification for existence. Noting that the Internet and cellular telephones have now made Amateur Radio no longer the only way to communicate worldwide, even from our cars, the one thing ham radio can do is to help amateurs to learn and to teach others. He maintained that it is AMSAT's job to help people educate themselves and to provide them with technical insights.

Tynan asked for a clarification of the open source concept, noting that AMSAT might be able to help fund the development by licensing commercial manufacturers. Karn was adamant on the subject, replying that if a firm wanted to make the hardware for his project commercially available he would encourage them to do so, without extracting any royalty. He reiterated his offer to help fund the proposed project, saying he sincerely believes the project should be open, so that people can learn about digital technology, help with the work, and

A Proposal for an Efficient High Speed Digital Satellite Mode

Phil Karn, KA9Q

A new high speed digital mode is proposed for a future Amateur Radio satellite. The proposal is based on a system engineering analysis of the tradeoffs between the space and ground segments.

The project has one major design requirement: the ability to use small (<1m) ground antennas that can be erected in areas where conventional large amateur satellite antennas are impractical or prohibited. Other design goals include making the most efficient use of each kilogram launched into orbit, and minimizing the total system (space and earth segment) costs.

The following system features are proposed to meet these goals:

1. The use of microwave frequency bands, particularly the 23 and 13cm amateur satellite allocations, and possibly the 3cm band.

2. Power-efficient digital modulation and strong forward error correction.

3. A wideband, hard-limiting spacecraft transponder.

4. Time-division multiple access (TDMA).

5. Substantial use by the ground stations of the considerable digital signal processing (DSP) capability now available in personal computers.

have fun while doing so.

A question was asked about the complexity of the project and whether it might tax AMSAT's capabilities too much. Karn replied that in terms of today's technology, development of the ground station equipment would be comparable to the task that TAPR faced in designing the TNC 15 years ago.

A Low Cost Phase 3E Satellite Concept

Jansson, noting the desire on the part of many amateurs for a high altitude, DX, satellite to replace AO-13 and the aging AO-10, cited his papers published in the Proceedings of the 2000 AMSAT Space Symposium and in the January/February 2001 issue of *The AMSAT Journal*. He said such a *Phase 3E* spacecraft would employ a linear transponder to support multi-user SSB/CW operation. He then proceeded to suggest specific spaceframe configurations, payload modules, antennas and a power system. He emphasized that the proposed satellite must incorporate the *KISS principle*. To accomplish this he proposed that it be spin stabilized, have no on-board propulsion system and employ previously developed designs. Furthermore, he proposed that the objective should be a project that can be completed within 3 years of its initiation, at a cost of no more than $500,000. Of course, he noted, the elimination of on-board propulsion would mean that the spacecraft would remain in whatever orbit the launch vehicle put it into. He proposed targeting the Ariane ASAP-5 auxiliary launch platform, and noted that the resulting Geostationary Transfer Orbit (GTO) would have an apogee of about 36,000 km and a perigee of about 600 km - the same as AO-40 immediately after its launch. Many have noted that such orbits would be very satisfactory for amateur use, and that there are numerous launches to that orbit. It has also been pointed out that this is a stable orbit.

Jansson emphasized that the concept he was proposing does not necessarily preclude the inclusion of advanced technology payloads, as long as they do not jeopardize the primary objectives.

Use of Normal Mode Spacecraft Antennas

Lyle Johnson began his talk by comparing the disadvantages of low orbit vs. high orbit satellites that led him to consider what hams want in space communications. He noted that, from the user's perspective, the most important things are signal strength, signal quality, a wide footprint for DX and extended time availability. Furthermore, he observed, there exists a partnership between users investing in their equipment and the *techies* who want to build something which interests them. He opined that considering these things the LEO's had the most advantages for the user with the exception of a shorter time availability and smaller footprints. Nevertheless, the generous amounts donated by hams to the AO-40 project showed that prolonged availability and a larger footprint are important to many. He noted Jansson's proposed *Phase 3E* indicated that things can be simplified to solve some of the disadvantages of previous high orbit Phase 3 satellites. Building on Jansson's approach, he suggested that, contrary to the past practice of using axial mode antennas, employing normal mode antennas. He said that the principal advantage of this would be to increase usability throughout the entire orbit, at the cost of weaker signals at apogee.

Johnson proceeded to describe normal mode antenna design using dipole arrays, which would be relatively small, and showed their resulting radiation patterns. He then distributed a spreadsheet comparing uplink and downlink parameters to estimate signal characteristics. These included gain, polarization and frequency used vs. power out, satellite altitude, etc. L and S bands were considered to be optimum frequencies.

Jansson compared his design for a Phase 3E spacecraft to Johnson's proposal for a 600 mm square spaceframe and concluded there would be only a few watts difference in power generation.

An Improved On-board Computer

Johnson's other presentation involved a discussion of ways to reduce radiation damage to spacecraft computers in future high altitude satellites. The experience gained from studying the results of damage to the IHU of AO-10 and AO-13 was cited and he noted that, in 1997 the IHU2 that was flown on AO-40, was designed using modern components, namely a *STRONGARM* processor. He remarked that the results of that experiment are still inconclusive, and recommended that this processor not be considered for future projects until more radiation data is available on it. He emphasized that any of our designs be based on the use of radiation tolerant system-on-a-chip designs, or even the entire computer on a chip; and suggested employing commercially available radiation tolerant devices having built-in redundancy. He added that the inexpensive non-rad-hardened model can be used for development purposes.

Additional technical considerations for a new onboard computer were then addressed including improving the AO-40 design for analog monitoring. He added that he, James Miller, Bdale Garbee and Chuck Green have been discussing these matters and their thinking is that they could build 4 to 5 sample engineering boards for about $2000. Then, if it is decided to use the new design in a Phase-3-class project, the flight model could be built for $4500 or less. Johnson said that his goal would be to shrink the IHU down to a total of 4 to 5 chips with low power requirements and said he would enjoy working on such a project. He estimated total cost of the flight computer to be about $5000 to $8000. Garbee noted that the final phase need not be initiated until a mission is identified.

Further discussion followed and Johnson opined that problems with proprietary issues were not likely. McFadin said he would like to see improvements made in the I/O structure used by AO-40.

IV. Critiques

Karn's Proposal

It was generally thought by the Board members that Karn's proposal had merit. However, some expressed concern over its complexity. There was general agreement that a simple linear transponder, preferably on a satellite in high orbit was what the majority of members want. Nevertheless, it was acknowledged that one of AMSAT's aims has always been to provide incentive for amateurs to employ more advanced means of communication. Going to higher frequencies is one aspect of this. Certainly, going to improved modulation techniques would represent another.

King was invited to comment on the proposal, and noted that the satellite to carry a transponder suitable to support Karn's approach, could be built either smaller or somewhat larger than the Microsats depending on what requirements are placed on the ground station. He added that another feature to consider is what the *feel* of this new mode of communication would be, and wondered if, to the users, it might be something like a cellular telephone - and thus seem boring to hams. Karn, facetiously responded by showing, on a chart, how he could add fading, QRM and white noise to the system to make it sound more *ham-like*.

A question was asked if a strong interfering signal could capture the proposed transponder. Karn acknowledged that, because of the *bent pipe* nature of such a transponder, a strong interfering signal would capture it. Thus the system IS subject to jamming, he concluded. It was noted, however, that because the system would employ microwave frequencies, malicious interference would be less likely to occur.

King noted that another thing to consider is that, having only one LEO satellite available, accessible only 2 to 3 percent of the day, might be inconsis-

tent with our strategic goal of AMSAT developing satellites for consistent Amateur Radio communications. He asked how many spacecraft of this type would be required to support that goal, and could they be launched in a systematic way? Karn noted that an advantage of this type of satellite is that it is something we could afford to lose, especially if there are several in orbit. Soifer suggested the possibility of using satellite-to-satellite relays to extend coverage. It was noted that this is a technique generally untested by us. Karn noted that this is a relatively easy thing to do in the digital domain, and cited the digipeating feature of the TNC as an example.

Soifer asked if ground-based relay stations could be used for linking. Clark cited the now global linking of the APRS terrestrial network that uses the Internet to link selected points. Use of the Internet to expand packet networks and to link FM repeaters were also mentioned.

The idea was expressed that construction and launch of a fleet of LEOs to support Karn's concept might be handled by university groups, using designs developed by AMSAT. Such spacecraft could, of course also carry scientific experiments provided by each individual university group.

King pointed out that among the several directions that AMSAT says it would like to go, one is to work more with universities by 2002. Thereupon, he suggested designing a standard bus for various payloads and then taking it to the universities having students working on experiments that may have access to launches and then commingling their science data with our communications. An additional benefit would be that it might make us more credible within NASA as experimenters whereas we are perhaps now thought of only as technologists.

Soifer noted the problem that many of the experiments universities want to fly are not appropriate candidates for having their data transmitted down on amateur frequencies. He noted the spectrum space some of these projects might use, and that many university persons are generally unfamiliar with the requirements for licensing and operation in the amateur service. Although he agreed we should be involved with universities and that some of their projects are appropriate for the amateur spectrum, he observed that others may not be. The problem of how you handle potential conflicts when the university wants data transmission and the amateur community wants to be able to use the satellite was also mentioned.

Daniels cautioned that having universities build satellites is not free. It requires effort on the part of AMSAT volunteers to make certain things are accomplished in a satisfactory manner.

McFadin noted that the ISS program provides an opportunity every two years or so to put payloads on the Express Pallet and that it would be a perfect launch platform to prove the concept of Karn's project. He said the ARISS group is working to ensure that we have an opportunity to take up payloads. Tynan cited the paper presented by Matt Ettus at the last Symposium was a spread spectrum package for the Express Pallet. He stated his contention that the ISS, while not a very good repeater platform because of the ISS's relatively low orbit, it could serve as a good testbed for new systems such as that proposed by Karn. Haighton noted that an important aspect of the ISS is that it receives frequent mention in the news, and is a frequent topic of public discussion. Daniels added that many persons are motivated to be involved with anything that has to do with manned space missions.

Baines noted that if we are going to adopt Karn's proposal, we should begin doing developing the ground station equipment in order to have a head start if a launch opportunity appears.

It was generally agreed that the satellite portion of Karn's proposal is not the major problem. A relatively simple wide band transponder can accommodate it. The difficult task is developing the ground equipment. Tynan suggested that this be accomplished by TAPR, noting the close working relationship the two organizations have enjoyed over the years. In response to this, it was noted that many of the same people are involved with TAPR and AMSAT, so it is somewhat moot which organization handles the development. It was generally concluded, however that TAPR would be the appropriate organization to handle the kiting and distribution of the resulting equipment. This is a task they have accomplished for a number of devices, from the TNC on.

In an effort to air all views, particularly those of knowledgeable members who continue to contribute time and effort to AMSAT causes, Tynan then quoted from an e-mail from Jim White, WD0E. In it, Jim criticized Karn's proposal for a purely digital satellite because the bulk of users want satellites they can talk through in the old fashioned ham radio way. White's message then complemented the technical aspects of Karn's proposal and said that while it would be fun to work on, it is essentially a cellular telephone system for hams. Thus, it would require little skill to use. Karn registered strong disagreement with this contention, arguing that users can exert as much or as little skill as they want. They can simply use what others create, much as they do now by buying commercial equipment, or they can jump in and contribute something new. "It's their choice," he contended. White's message also emphasized that he wasn't saying that Karn's proposal should not be built, but he stressed that it not be the sole transponder aboard. It could be included along with a more conventional analog unit, he concluded. Garbee observed that including an analog transponder negated much of the power advantages of Karn's all-digital system, because the spacecraft would have to carry enough on-board power to support the analog system. He contended that, if only the digital equipment was aboard, a power saving would result. Karn expressed strong agreement with Garbee's remark.

With regard to the *cellular telephone* nature of the digital communication with Karn's system, Tynan noted that that is not necessarily bad. It has been demonstrated, he said, that hams like to use terrestrial repeaters, which also feature clear interference-free communication.

Daniels responded that it is a serious question if we want to build for the past, or for the future - and agreed that we should come up with something that embraces both approaches. He also agreed with White that if the satellite is purely digital, we will lose financial support from most of our members.

Soifer opined that surveys of our members have shown that we have 3 to 5 different user populations, and that they are constantly changing. He added that 5 years ago, he would not have believed that many hams would be interested in APRS, yet Kenwood has sold 100,000 APRS-compatible transceivers. So, he concluded, that although there may not be many hams interested in Karn's satellite today, in 5-10 years there may be many. He contended that we should do the preliminary work, and that now is a good time to begin. He noted that a large percentage of users probably want another Mode B transponder, but that over time they will probably be willing to migrate to the microwave bands, just as they migrated from Mode A (2 to 10 meters). Although only a small percentage now have Mode S capability, a high altitude spacecraft will certainly encourage its acceptance. He estimated that $500,000 is not an unreasonable amount for us to spend over 3 years for the construction of a new satellite, provided we are reasonably certain of a launch opportunity. Baker noted that this is about 1/8 the total amount expended on AO-40. Soifer suggested that we could afford to dedicate a tenth of that now for design and prototyping and then authorize procurement when a launch opportunity is identified. Daniels commented that we have some time yet to decide on the exact configuration of the structure, noting that things beyond our control can change. He cited the example the design of Phase 3D which had to undergo a major change because ESA changed its requirements. He urged that in the meantime we should be spending our effort developing small, well-designed modules that could fit whatever spaceframe we might ultimately come up with. At the same time, we should be starting a major effort to develop major contacts with launch providers.

Clark addressed White's comments concerning preserving the status quo and he said we have always faced the dilemma of whether we are leaders or followers. He said that, given that the time required to do a project is 3 years at the minimum or as long as 10 years in the case of Phase 3D, what will be the attitude be then? Thus, he agreed with Soifer's contention that hams do change in their perception of what they want. He related how, in 1974, he had written a computer program for use in tracking Phase 3A, and as a result, received angry mail stating that "hams will never have computers."

Jansson's Proposal

A discussion of the ASAP-5 resulted in an extensive examination of possible spaceframe configurations that it could accommodate and still meet requirements for solar power generation and antenna placement. The pros and cons of various types of antennas were discussed in detail, and Jansson proceeded to describe other proposed onboard equipment. McFadin asked about the issue of solar panel heating, to which King replied that he thought the presence of open spaces beneath the solar arrays might be helpful in this regard.

Tynan noted that he preferred a configuration similar to AO-40 although much smaller - but acknowledged that a four sided design could also be used. He said that such a spacecraft could spin in the orbital plane, thus easing the thermal problem. He envisioned whip antennas coming out the top and bottom and electronically de-spun gain antennas for the microwave bands mounted on the top and bottom, or built into the spaceframe. Such a design seemed more elegant to him, and he noted that a spacecraft of this type could serve the need for a linear transponder to replace AO-13, as well as a microwave transponder to support Karn's concept. He agreed with the concept of not having on-board propulsion, thus utilizing the GTO orbit in which the launch vehicle placed the satellite.

In response to this, several stated that simple whip antennas would not provide adequate signal levels at apogee. However, Soifer said that his calculation showed a whip antenna to be adequate for V-band downlink because the path loss is lower than at S-band.

Johnson's Antenna Proposal

Clark called attention to the effect of sky temperatures at various frequencies and asked if he had

considered electronically despun antennas. Johnson's reply was "no, not for this purpose" although he agreed that higher gain would be achieved with them. He emphasized that he was aiming for maximum simplicity.

King noted the effect of Faraday rotation at 2 m and 70 cm and how this changes the polarization of a plane polarized wave. He noted that this effect would be much less at S Band. The group shared their experiences with past satellites in this regard. It was noted that this effect could be eliminated by the use of circularly polarized antennas on the ground, on the spacecraft, or both.

Clark noted that Jansson's and Johnson's proposals are really the same and could be merged into one project.

Johnson's New Computer Design Proposal

The point was made that previous designs, while possibly sound, used components no longer readily available. The rad-hard 1802s used in the AO-40 spacecraft IHU were found in someone's drawer. We cannot depend on locating necessary hardware in this manner in the future. The Board members, and others present, generally thought Johnson's approach was sound.

V. Obtaining Launches

A lengthy discussion ensued concerning the increasing difficulty of obtaining launches for any amateur satellite at costs we can afford.

It was noted that Jansson had proposed that his *Phase 3E* bird be launched on an Ariane 5 ASAP platform. It was noted that it was the Ariane 4 ASAP platform on which the 4 Microsats and 2 UO-sats were launched in 1990. A number of other piggyback payloads have been launched from it since. Also, several secondary payloads have been launched on the Ariane 5 version.

Clark remarked that much of our focus seems to be on high orbit missions, and reminded the group that we should also consider LEO projects; adding that, unlike what the commercial world does, we need to do what others are not doing. He also noted that past experience has shown that the launch opportunity must come first, followed by a spacecraft design to take advantage of it. He also expressed concern that we are not nurturing launch opportunities. He strongly suggested that we not neglect the low orbit approach and noted that our previous LEO satellites frequently accompanied scientific payloads launched by NASA. Clark urged that we not rule out this kind of opportunity, and contended that the LEOs AO-6, -7, -8 and the Ariane-launched Microsats were the AMSAT products most appreciated by amateurs. Their common thread, he noted, was simplicity and being managed and built by a small team that worked together easily. He also said that the educational community continues to produce LEO satellites, many having received federal support, and launches. He contended that we should work with them to help them define their missions and at the same time provide spacecraft that would be interesting and useful to amateurs.

King remarked that relations with Arianespace remain good. However, he commented that the commercial cost to launch a satellite of the size described by Jansson to GTO would be approximately $3 million. All were in agreement that such a figure is beyond amateur resources, and that we would have to seek an adjustment to that price. Strategies for obtaining an Ariane-type launch were discussed, including finding a mission that already has an ASAP-5 ring passenger that requires balancing ballast in which our spacecraft might be able to act as that ballast.

King noted that he still had contacts with Arianespace, and suggested that he might be able to set up a meeting to discuss the possibility of future AMSAT launches. He took an action item to do this.

King suggested that a logical way to approach launch agencies would be through a university connection. He noted that integration costs have increased dramatically, e.g., from approximately $100,000 for OSCARs 6 and 7 to the $2 million per payload that Boeing is asking to integrate a small payload most of it for paperwork. He concluded that it will be difficult to get a US launch. Tynan added that he thought that our best bets are with the Russians and Arianespace.

McFadin commented that many satellites are launched with a defined lifetime for their primary mission, and that an included amateur package could be activated following completion of that primary mission. He cited UO-14 as an example, and suggested that an amateur transponder might be included as a passenger on some such future spacecraft. In particular, he mentioned the possibility of such a transponder to support Karn's proposal.

Daniels noted the potential effect of the advent of recently enacted, stricter U.S. Government ITAR regulations can have on cooperative arrangements with overseas collaborators. Comparisons were made with the relatively easy arrangements made for AO-40. Daniels said that although we followed the rules then concerning technology transfer, there are now even more stringent requirements that must be fulfilled.

Another tactic considered for obtaining a ride might be to purchase space on a launch and then act as a broker for any space available beyond our needs.

McFadin noted that the Russians are building some small educational and ham satellites that will be shipped to the ISS on the Progress mission for release. He asserted they would welcome AMSAT to participate in such projects, for a price.

Baker suggested redirecting AMSAT into a DARPA-like organization to prepare designs that would be brought to a certain point and then developed into standard modules and systems that are known to fit a known lifting structure.

VI. Choosing a New Project

Haighton noted that we have been presented with two basic proposals: Karn's digital modulation scheme, and the Johnson/Jansson GTO spacecraft. He said he wanted us to consider both. Tynan suggested combining them. He saw no reason why we cannot aim for a spinning spacecraft that would remain in GTO which could carry a linear transponder a-la AO-10 and AO-13, plus a microwave transponder to support Karn's proposal. He maintained that, as proposed by Jansson, such a spacecraft should be designed to be a simple as possible, consistent with accomplishing its mission. He stressed that, to adhere to the KISS concept, nothing should added beyond that necessary to support the satellites's Amateur Radio communication mission, even if there is space, power time and money available to do so. A discussion followed regarding what bands should be used for the linear transponder. It was generally agreed that V-band produces difficulties because of the size of the spacecraft antenna required if a gain antenna is employed. This becomes a particular problem if the spacecraft is small. L/s and L/u were mentioned. Soifer recommended a U band uplink rather than L band, but Tynan argued that an L band uplink and a U band downlink would be a more optimum combination. He noted that the cost of L band ground station transmitting equipment is now fairly reasonable. Transverters are readily available and some off-the-shelf radios include 23 cm capability. The use of U band at perigee was noted as being beneficial.

King contributed many ideas concerning appropriate antennas for the spacecraft that included dipoles, collinear arrays, discones and tape-measure antennas. The subject then turned to recent advances in solar cell technology. Tynan, although admitting he was no expert on solar cells, expressed the feeling that gallium arsenide cells had advantages over silicon, because of their higher efficiency. Therefore, on a small spacecraft, where real estate is at a premium GaAs cells make sense because of the higher power they generate. He noted that their disadvantage is cost, but contended that the labor of laying down the cells, whatever the type, is the major cost. King generally agreed with this, and acknowledged that these higher efficiency cells should not be rejected out of hand.

Noting White's e-mail comment, Tynan stressed the need to have both analog and digital transponders on any new spacecraft, doubting that donations would be forthcoming from hams to construct a purely digital system.

Clark urged that Karn's proposal be authorized to proceed, with an initial goal of constructing equipment suitable for a terrestrial demonstration. He suggested that this be introduced to the amateur community at the Dayton Hamvention, hopefully by 2002. Tynan agreed, noting that the orbiting component to support Karn's system would be a relatively straightforward transponder, but that the user equipment represents the major technical challenge. He asked about the resources available to develop the necessary hardware, to which Karn replied by comparing the complexity to that of TAPR TNC at the time of its development in the early 1980s.

Tynan asked how to start moving with Karn's proposal noting that Phil has already put some money in and urging that it must be used wisely. Talented individuals are needed to work on the project, he said. Daniels suggested promoting the need for volunteers in *The AMSAT Journal*. The volunteer ethic for getting things done was then discussed at some length, and it was agreed by all that this is very applicable to this phase of the project.

Tynan suggested that Karn write an article for *The AMSAT Journal*, describing his approach and asking for volunteers to help work on it. Karn agreed to do this.

Clark noted that he interprets the Board's intent as placing Jansson's and Johnson's as similar proposals high on the priority list. Therefore, he said, these two should work together to decide on a configuration that might employ common features.

Before adjournment, Tynan requested a few minutes to tell about the Acrylic Engine recently developed by a group at SpaceDev in California. He said that this is to be a low cost stage for secondary payloads. It should answer the problem of what to do if you get a ride into space but it's not to the correct orbit. Their answer was to develop an engine that will restart 4 times and provide enough thrust to move a 50 kg spacecraft at 300 to 500 m/sec from GTO to a higher orbit. The propellant is acrylic plastic with bottles on the outside contain-

ing nitrous oxide so it's considered to be a safe device that could be flown on the shuttle. King commented that there may be several places where we could go to get a motor of this type.

The meeting adjoined at 1730 EST Saturday evening and reconvened on Sunday morning at 0810 EST.

VI. Project Management

On resuming the meeting, Baker read a report from Peter Guzelow, DB2OS concerning the recent reduction of AO-40's spin rate.

Haighton noted that, over the years, AMSAT was frequently approached by people with ideas for projects they thought we should undertake. Previously, it had been pretty much up to the President to decide on the merits of such proposals and make recommendations to the Board for those he believed viable and worthwhile. Haighton said that he thought that a technically qualified group should be set up to examine such proposals and make recommendations to him for passing on to the Board. This is why he set up the Projects Committee. The committee he appointed consists of members with diverse backgrounds and includes: Burden, Garbee, Gilchrist, Jansson, Johnson, Kanawatti, Marchant, Mills, McFadin, Shultz, White, Wood and Ernandes. Tynan recommended that, in view of his unique knowledge and experience, King be added to the Committee. King agreed to serve.

Haighton reported that the Projects Committee members who were in Orlando for this meeting had held a breakfast meeting to discuss the presentations made the previous day. He said, they also addressed the subject of management of any new projects, and reported that their conclusions will be included in their next report to the Board. With regard to project management, those Projects Committee members present in Orlando recommended the following general guidelines concerning an AMSAT project: 1) It should be North American led, with other international partners participating as appropriate. 2) The Project Manager should be appointed by the AMSAT President in consultation with the Vice President for Engineering and following recommendations by the Projects Committee. 3) The Project Manager must be able to work well with the Committee. 4) The Project Manager will be responsible to the Vice President for Engineering for all technical matters who will report monthly to the President on the status of the project, and to the Board at its meetings or at the end of each phase of the project. 5) The VP Engineering, the Project Manager and the Treasurer will work closely with the Corporate Secretary to develop a financial system showing project expenses and income on a monthly basis. Haighton noted this worked well during AO-40 construction and that it should provide a model for future projects. He said further that he would also like to receive information about the amount of donations and the value of software, hardware and time expended by individuals.

It was noted that some of these guidelines, particularly those regarding management from North America, represented feedback received from AMSAT members as well as from Board members.

Daniels commented on the above plan with the opinion that, in his experience, those volunteers who are the most productive, are those least likely to be interested in generating the paperwork called for. Tynan replied that AMSAT's approach to AO-40 construction was more business-like than our previous efforts due partly to having full time employees and to a large extent that Baker carefully tracked the expenses with the help of the Treasurer and Corporate Secretary who already had a system in place that facilitated the gathering of such information. He suggested that, because of its size and the amount of money involved, AMSAT must move toward the corporate/NASA strategy. Acknowledging the fact that volunteers do not want to spend their time producing a lot of paper; he agreed that we must walk a fine line between the way hams like to do things and the more formal methods employed in Government and industry.

Haighton explained that he was looking to the Board to act as a gate mechanism where they are satisfied at the end of each phase of a project so that they can be in a position to release funds. At this meeting, he noted, we are at the preliminary phase of providing an outline for a project, or projects; and seek basic Board approval of the concepts involved. Then, he said, we have to take that back to the Projects Committee to look at details, including a possible marriage of the Johnson and Jansson proposals. Haighton then asked the Board to fund a suitable meeting of the Projects Committee similar to this one and start work on these ideas so that once the basic parameters have been established they will come back to the Board with their recommendations and a request for approval. The second phase is the preliminary design and the third will provide details and parts lists.

Garbee opined that making the process this involved might frighten away *tekkies* for whom part of the enjoyment of working on AMSAT projects is a lack of paperwork burden. Clark commented that *design review* here should at least be changed to *peer review*. Daniels added that *review* has the connotation of an external critique where a defense of the design is required and that doesn't work well in our environment. King said that the environment depends on everybody being as smart as they can on the project and the team works in a supportive way with a good cross flow of information in all directions, and when that process working everything is fine. Further comments were made about the Project Manager structure and it was stated that, while in the past there has been one, that person has been higher on the organizational chart

than was shown on Haighton's chart. This is necessary so he will have the authority to commit the organization when dealing with outside groups. King reminded everyone that for a long period he as the VP for Engineering was also the Project Manager. Tynan noted that, because of the change in who our officers are and the fact many of them have full-time jobs, that approach probably won't work now. Clark, citing how with AO-40, as the complexity of the satellite grew, so did the number of people involved in it who didn't have full knowledge of the entire system. Therefore, he recommended that the team for any new project be kept to fewer than 20 persons. King remarked that that was about the right number, stating that one person cannot direct more than 20 people. He also cited the axiom that when working with volunteers, "you can get a person to do exactly what they want to do." Therefore, progress can be made only when there's an alignment between management's needs and the worker's wants.

Tynan commented that perhaps we have not fully trusted the abilities of new people and therefore may have discouraged those who are not persistent enough. Daniels noted that some of our most productive people were those that had to force their way into the system. A discussion followed of ways to encourage talented new volunteers. King said that the Board members should work toward finding and mentoring younger persons for all AMSAT positions.

Haighton contended that the requirement that the builders periodically return to the Board to ask for the next stage of funding would make it difficult to expand it to an AO-40 type of program.

Soifer and Daniels noted the top down nature of this approach, and that it departs from much of AMSAT's previous way of doing business. King questioned the use of the phase approach, also because it is contrary to the previous AMSAT approach where the volunteers were referred to as experimenters and the work was a peer driven, self reviewing process that had worked well for us.

Tynan advised that we will probably have to pay someone, at least in the final stages of a project if we are to get the job completed in time to make whatever launch we can get. He admitted that he wasn't happy with this, but expected that it would be required, as it was for AO-40. In contrast, he and the rest of the assembled group were adamant in vowing that we would not get involved in a project as complex, expensive and time consuming as AO-40.

Daniels commented the role of the Board has changed considerably since it was formed when it was mainly composed of those persons doing the work and meetings were held monthly. However, not many of the Board members are carrying out the projects now. They now seem to be separate organizations, with the Board deciding what will be done. Haighton replied that the Board is elected by, and are responsible to, the membership. Tynan suggested that new candidates for the Board become known by writing articles for *The AMSAT Journal*. Those who are known, he said, are most likely to get elected.

Tynan took exception to the prevailing opinion held by some, e.g., if it's a LEO satellite - it's simple. He maintained that the satellite's altitude does not have a great deal to do with its complexity. Instead, he insisted, complexity has more to do with how many things you want the satellite to do. Karn argued that the additional power requirements for high altitude spacecraft does add some complexity. Clark contended that high altitude launches are more costly. King countered that the most likely launch opportunities are now to GTO, because that is where the non-military spacecraft are going. Tynan stated that because LEOs have a brief period of availability, therefore you need more of them, thus negating some of the simplicity some attribute to them.

VII. Fund Raising

Haighton told the group that he had asked Vice President for Development Shepard to attend the meeting and give a presentation on his views with respect to fund raising and getting the AMSAT message out.

Shepard began by reviewing his background in sales and marketing, citing his experience in working with engineers. He then mentioned how several years ago he was asked by Baker to assemble a program to raise funds for AMSAT from foundations and to make appeals to vendors for the donation of components. A binder containing printed material describing AMSAT was prepared and this was somewhat successful in that it raised $20,000 to $30,000 plus successfully obtaining parts for AO-40 from some large companies. He said we learned a lot from this, namely that we have a limited constituency (hams) and that foundations in general are uninformed about Amateur Radio and the good it does. Shepard estimated that for every dollar that we put into a properly run fundraising effort, we should be able to get $20 to $30 back. He then discussed objectives and specifics of sales and marketing, suggesting that we expand our constituency beyond Amateur Radio to include educational institutions and corporate entities. Clark added government to this list. Shepard continued that we also need to do a better job of communicating with hams by improving our information and materials for distribution as well as stressing the contributions we make to the Amateur Radio community. He described the concept of positioning and said its basis is a perception of what you are and is often expressed by a slogan. He said that we are now perceived as an Amateur Radio organization that builds and launches communications satellites, and contended that we must stress the theme that AMSAT is a non-profit, educational and scientific organization. We have a strong story to tell, and must learn to tell it better, he said. This story should be included in the marketing material we need to create, he insisted. However, he cautioned the group that one can't claim one is something one is not - although some marketing license can be taken.

Shepard continued his presentation urging that we leverage AMSAT's 40 years of accomplishments in space and education by emphasizing its involvement with SAREX, the ISS and universities. To do this, he proposed a formal marketing program starting with market research. He emphasized the major problem is that people don't know who we are, especially those outside of Amateur Radio. He then asked for help in collecting the information and distilling it down into positioning statements and collateral materials. Specifically, he said, we should develop a 4-page color handout titled *This is AMSAT* telling of our heritage and plans for the future. Tynan noted that there was already much written material available including fund raising letters both he and Clark had written, and that these might serve as a beginning.

Baines questioned the need for market research. Shepard's reply was that "sales begin with a good list, and we need a good list of the highest probability prospects in all the markets we're dealing with."

Shepard noted further that AMSAT's public relations effort has been almost nonexistent recently, so he recommends that we become associated with a good public relations firm. He said that such firms are numerous and relatively inexpensive. The advantage is that a big PR firm can get you places you can't get to by yourself. Tynan described some past AMSAT PR efforts that were moderately successful, but admitted that we have often been ignored when trying to get things published. He noted that MacAllister has suggested that AMSAT members write articles for *The AMSAT Journal*, and then rework them to have them available as an inventory of articles for publication outside the amateur community.

Shepard said that although the AMSAT Web site is a great source of information, we should put some marketing into it. Baines agreed and said that we will have that opportunity since we have acquired the domain name *amsat-na.com*. Shepard went on to say that another short-term thing we need to do is better PR regarding AO-40, mainly for the amateur constituency. We need a cautious approach toward our responses and should have a rapport with the press so they can directly get answers to their questions about its status. It was noted that the ARRL has been cooperative, drawing material from ANS. Shepard next addressed Haighton's objectives concerning fund raising saying that $2 million is a long stretch but contended that we should have it as a goal. He commented that we should try to find more of kinds of situations such as MOST to assist in the fund raising process. Tynan noted that we have done many projects in conjunction with universities that we can cite including e.g., MOST and Jansson's work with Weber State University. A few examples were cited of where a philanthropist's interest in a project had been aroused. Shepard said that's why we must emphasize what we're doing with SAREX and the ISS.

Tynan asked Shepard if he is now available on a continuing basis. He replied that Haighton had encouraged him to again become active in raising funds and that he is interested in doing so, but to learn what opinions the Board had toward such a campaign. He indicated his availability if the Board chose to go ahead with the campaign he had outlined.

With that statement he went on to propose an initial sales and marketing program that would cost $40,000. Baines asked "what do we get for the money?" Shepard replied, first a brochure of high quality for $12,000, and development of the marketing component within the Web site for $3,000 more. Tynan commented that this sounded like a lot of money. Shepard's reply was that, for a truly professional job, it was not. He said further, that he would like to get a public relations firm started on this soon, e.g., getting a proposal and to try out the firm with a few press releases. He went on to explain that $5,000 would be needed for telephone efforts, $10,000 for travel and $2,000 for miscellaneous expenses. Tynan asked if the Treasurer had been notified of this and the reply was "not yet." In response to a question about the duration of the PR effort Haighton explained that what he was proposing was enough to get started and added that a definite answer could not be provided but he thought we could find a firm with the appropriate experience. Clark, noting that we had frequently shared resources with the ARRL, asked what firm they used. Shepard said he would look into this. Clark added that the current thrust of the ARRL was with educational material.

Shepard then went on to the subject of management of risk saying there was no certainty that $2 million could be raised because of the magnitude of the challenge, yet he thought it certain that the

$40,000 investment would be recovered and that 6 to 7 times that investment was attainable. By spending another $80,000 a return of $1.5 million might well be realized, he contended. Tynan noted that, although professional help might be beneficial, AMSAT's ability to raise fund depends more on us having an exciting project to highlight. He noted that we had highlighted education, but to raise significant money we need a *shiny satellite* we can picture in a brochure. Daniels asked if we would get periodic reports from the PR firm and the reply was it was like a grant proposal in which you receive them periodically. Haighton asked how long it might take to get a return of $1.5 million and the answer was 2.5 years as had been suggested earlier. Shepard added that with the Board's concurrence he will write a marketing plan and, if that is approved, we could get started immediately preparing a brochure that would require about 3 months to complete.

Haighton then moved to allocate $40,000 now to explore marketing in a professional manner. Clark seconded the motion.

After further discussion particularly with respect to the amount of money to be expended on the brochure, the motion passed by a unanimous vote.

A discussion followed about whether the new Fund Raising Department could be charged to the budget for Development. Baines noted that we already have a Fund Raising Department and it presently has $20,000 allocated to it. Haighton added that there is also a blank department number that could be used to keep this particular item separate until we see how it performs. The Treasurer will be consulted as to how it should be set up.

VIII. Critique of the Proposed Satellite Projects

Tynan said he wanted some kind of decision before adjournment on new projects, e.g., Johnson's new IHU computer, Karn's ground demonstration for a new mode scheme and the GTO Jansson/Johnson spacecraft. Johnson declared that what he and Jansson had proposed were satellites that satisfy a perceived set of needs with the essential differences being in size, mass, signal strength and window of opportunity. He added that there is risk with his proposed antenna system because it has not been done before and stated that neither he or Jansson are the right ones to decide which is best. Haighton reminded everyone, that he had already tasked the Projects Committee to make that determination and provide the Board with their recommendation.

Johnson inquired about who is supposed to make the decisions about long range planning and projects and what is the role of the Board? He expressed concern that the Board was taking the bureaucratic approach putting off a decision pending more study. He said he would like to see this meeting come to a decision.

Tynan agreed, saying that he was hoping that what would be forthcoming would be an intelligent combination of Karn's proposal and the Janssson-Johnson design, but saw no reason why we had to decide between Johnson and Janssen at this meeting. He saw the two as differing only in detail. Both are for a relatively simple satellite that would go into GTO and carry a linear transponder compatible with the equipment already in the hands of many satellite operators. However, he saw no reason why it could not also include a microwave transponder to support Karn's approach.

Baines recommended that a decision not be made about flying Karn's project until it had been successfully demonstrated on the ground. Clark agreed that the logical development steps were needed for Karn's scheme. Tynan responded, saying they could be done in parallel with the spacecraft development.

IX. Funding of New Projects

Tynan asked for a motion to fund the development of the new computer proposed by Johnson, noting that it will be needed no matter what satellite project is built. Clark moved that $5000 be allocated to develop the new computer, Haighton seconded, and the motion passed by unanimous vote.

Tynan then returned to the subject of Karn's project to develop a new mode for satellite communication, saying that this possibly could be done in conjunction with TAPR. He added that he'd like the ground demonstration part of the project to get started for possible later inclusion in a satellite.

Daniels reminded the Board that Karn had suggested using a cluster of satellites in low orbit, not a high altitude bird.

Further, he contended that any approval granted to Karn's project should anticipate that it will eventually be flown, once it has been proven. Daniels reiterated, however, that he is still in favor of the next project being small, simple and short term.

Baines stated that he thought that, in terms of technological development and risk, Karn's design looked to be a longer term development issue rather than the building of a more traditional satellite for GTO, but agreed to the concept of a ground station demonstration to make certain that it will do what is claimed for it as well as to sell the idea to the amateur community. He asked about the possible downside risk, to which Karn compared it to the risk associated with the development of the TNC. In response to a question about the PR risk, Tynan responded that it's just the opposite of a risk, because it represents a technology advancement that AMSAT can point to and Shepard can cite as something AMSAT is doing in education, science and engineering. Garbee added that the appealing thing is that the space segment is so straightforward and flexible in terms of what platform it can fly on and there's no reason why it can't be on GTO, a LEO or on the ISS. It's interesting development work to be done, plus it's a noteworthy project that doesn't require a lot of travel, vibration tests etc. King declared that we need a breakthrough in radio communication and a new mode of operation. A possible step beyond is the marketing of a new mode and we have the opportunity here to make it happen, and if we don't do it, we will have no opportunity.

Baines commented that we are accepting a new responsibility, i.e., that we're not only going to develop a satellite, but also a system that includes ground station development so there are not only the technical issues of construction, it must be made affordable for amateurs and production and logistic support must be in place. The response was this is the role that TAPR can be expected to play. Baines answered we don't know what TAPR's response will be, but we do know that it has its own problems in terms of its ability to get its own projects out. Karn answered that he perceived that TAPR's problems are with development, not on the logistics side, and if TAPR doesn't want to do the logistics there are TAPR people in AMSAT that can handle it. Daniels asked about the risk of not getting a launch in the near future on an Ariane 5 because that too is a long shot. Tynan responded that the risks are all interrelated, and summarized saying that we would like to proceed with the ground station development and with a demonstration space segment at the same time that we're pursuing preliminary design of a Jansson/Johnson GTO type of spacecraft; all the while trying to get the assistance of a Arianespace persons in arranging for a launch. He noted that King had already agreed to pursue this.

Daniels commented that the approach to Arianespace is possibly more important than whether we agree today to fly a GTO satellite, so we need to know where we stand before we make a commitment. Clark advised that if an urgent decision is needed here, the statement to Karn should be yes, we're receptive to this new communications scheme. Let's start the initial work and get something going. Then, if a viable opportunity arises and the flight system is well enough defined by then, go ahead and fly it either on a GTO or LEO craft. Once we get a prototype running we can start a real design.

Tynan asked Karn how much funding would be required to build a demonstration type space segment plus at least two ground stations? Karn replied that he wasn't familiar enough with hardware costs to give a good answer.

The discussion returned to the subject of the Jansson/Johnson satellite proposals with the advantages of a low inclination orbit being considered. Although there are only few problems involving sun angles there is the need to maintain the attitude of the spacecraft and both of these designs have a low perigee with magnetorqueing not a problem. A lengthy technical discussion followed that included constraints on antenna requirements, shape, dimensions and solar cell placement. Clark advised that the tradeoffs are too complicated to consider here, and that we need a list of options and link calculations. He concluded that the concept of the Jansson/Johnson designs is what we want to do, but in terms of details no one knows which is best.

Tynan returned to the question of whether the ground station phase of Karn's new mode project and should be authorized. Clark suggested a search for talent to soon have an AMSAT-funded weekend meeting in San Diego of 6 or so appropriate persons to try to home-in on what the hardware should look like for a ground demonstration of at least one repeater plus two or more user terminals. Clark estimated $10,000 as the cost for travel and prototyping the hardware and he noted that this is significantly less than Karn has already donated for this, and thus this is a project for which funds have already been arranged. The Board needs to ratify this, with Karn's concurrence, he added.

Clark then moved that an initial meeting be planned to start the development process, at a place to be determined soon and with a budget of $10,000. Haighton seconded, and the motion passed by unanimous vote. Karn was thanked for his technical and financial contributions.

King was thanked for attending and he departed agreeing to the request that he talk to Arianespace to let them know that we are still interested in launch opportunities, especially involving the ASAP-5 platform.

Tynan then asked for a vote to give the go ahead to Jansson, Johnson and Wood to begin the design effort to develop a satellite incorporating the features of the Jansson and Johnson projects, as developed further by the Projects Committee. Jansson restated his contention that the structural differ-

ences between these two are very significant. Johnson stated that regardless of what decision was made, he will do his part.

Haighton suggested that the Projects Committee should include in their report, projections of cost, time schedule and other aspects. Johnson noted that this is asking a lot.

Baines asked if an AO-13 class ground station would be adequate for working the projected spacecraft? Additional discussion of link requirements followed as were the public relations aspects. Clark advised that one of the deciding points between the two designs is choosing between S band vs. VHF (Mode B) and he noted that Johnson's system should easily accommodate Mode B if that is what's wanted so aren't we choosing between an old mode vs. moving up to the microwaves. Tynan noted this isn't our first foray into the S Band and added that the most arrangement most saleable to hams will be 2m/70cm combinations. Additional comments followed and Baker declared that more discussions are needed. Tynan summarized saying that we are definitely interested in a ASAP-5, GTO satellite if we can get a launch.

Tynan then asked for the consensus of the Board that we want to build a GTO satellite of about the size of the Jansson/Johnson proposals, with a configuration yet to be determined, and aimed at an ASAP-5 launch-opportunity. He added that he'd like to encourage the Projects Committee, plus whomever they need to consult with, to make their recommendation. Clark agreed to this with the exception of the inclusion of a statement about ASAP-5 because it puts us in the position of having to go on an Ariane and he recommended rewording this to use the term *small (less than 100 kg)* satellite for GTO with an uncomplicated propulsion system, having U/V modes and a simplified design. *Tynan then offered a sense of the Board resolution to that effect and that the Projects Committee, and whomever they would like to include, be encouraged to finalize a preliminary design. Haighton so moved, Clark seconded and the motion passed by unanimous vote.*

Haighton recommended that the Projects Committee meeting be held in late May 2001.

Clark offered as a motion another sense of the Board resolution to state that we are all very encouraged by the design proposed by Phil Karn, and we hope that it will be ready to be included on the GTO mission. Several persons seconded and the motion passed without opposition.

Tynan asked Karn to write an article for *The AMSAT Journal* outlining his proposal for the new mode. He noted that this would serve two purposes: a) inform the membership about it and its advantages, and b) form a basis for fund raising material. Haighton announced that he would work with Dan James to prepare an announcement for an ANS release describing the Board's decisions regarding these future projects.

X. Other Items

Internet Domain Names and the AMSAT WWW Site

Baker brought up the issue of AMSAT domain names and WWW sites saying that the individual who had registered amsat.com and amsat.net has renewed them for the next two years. It was noted that, at the last Board meeting, the domain name amsat-na.com had been registered and it could serve Shepard's plan to have an enhanced Web site for promotional purposes. Baker then recommended that we also obtain the domain amsat-na.net and Clark recommended that Paul Williamson be asked to do the registration. He urged that any Web site we use for fund raising purposes, should be separate from *amsat.org*. Tynan declared that anything we do along these lines should have Williamson's concurrence and a recommendation. That met with general agreement.

LEAST

The LEAST (Lots of Extra Amateur Stuff on the Telescope) project that is planned to fly with MOST was described by Johnson as consisting of two circuit boards, one digital and one RF. The digital board has been laid out and one has had parts installed by Chuck Green. Garbee reported that the RF board is now laid out with the help of John Connor and is relatively straightforward, consisting of a combination of pieces originally designed by Matjaz Vidmar. It is anticipated that the LEAST equipment will be shipped to Toronto by May 2001.

MOST

Haighton reported that he had recently talked with Dr. Zee of UTIAS and learned of a minor problem with the computer, and that Johnson had been asked to help. They are presently looking toward integrating LEAST in May and possibly having a meeting of LEAST and MOST workers in Toronto in May or June. Tynan inquired if they have hardware built for MOST. Haighton replied in the affirmative. He added that they are realizing lately that much of AMSAT's critique of their project is correct, and that UTIAS is generally pleased with the help AMSAT has provided them. Tynan reiterated the hope that we are documenting our recommendations, to which Haighton said we were. He added that MOST now hopes for a launch in 2002.

ARISS

McFadin reported on the status of ARISS saying that we now have Amateur Radio hardware installed on board the ISS. This includes VHF and UHF transceivers and a packet module. These use antennas originally designed for VHF telemetry on another frequency, but work very well, providing strong downlink signals. The astronauts have made school contacts and that activity is going well. He admitted exasperation on the part of some hams because the astronauts talk daily to their families, but very few contacts with general ham population take place. The hope was expressed that this situation will improve in the coming months. Another problem is that the battery on the packet module ran down due to mishandling on our part and the crew has not been able to take one of their laptops to reload the parameters, so no packet has been done. The plan is to send up a new packet module with a new battery. Meanwhile, a new crew is going up in about three weeks, he noted.

McFadin said, further, that the next big activity is taking up 4 antennas built by the Italian AMSAT group, one of which he displayed. He explained that these have a clamp to attach them to the handrails. The Russians planned to put a 2 GHz antenna on the service module for their short range TV system used for EVAs and have agreed to let us use the same cables for 2 m, L and S bands. He then showed photos of the Russian service module, on which the antennas will be mounted. He added that we will have only one opportunity to get them up and mounted, and noted that the Russians have been very cooperative on this. He noted that the cost of sending things to the ISS is approximately $25,000 per pound.

McFadin concluded, saying that there will be a meeting with the European partners in early May, at which time it is hoped they can discuss the Express Pallet and its experiments. Tynan asked if it would be worth introducing the idea of a possible 2.4 GHz spread spectrum experiment at that time, to see what the reaction would be. McFadin responded that he hopes to do that. Tynan remarked that he'd heard that 2.4 GHz was not acceptable because of regulations in some countries and wondered if a low power, relatively narrow band transmitter would be permitted. McFadin answered that we could likely get by with it and possibly even more. He recommended that the USA put forward a proposal for the Express Pallet and added that is was hoped to have the requirements defined by May so that he can announce the limits allowable on the Pallet.

XI. Acknowledgements

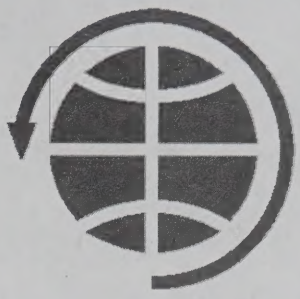
Clark began the wrap-up of the meeting by providing a list of *attaboys* recognizing recent noteworthy achievements. First, those individuals involved in the AO-40 effort who have distinguished themselves and are worthy of special commendation, namely the Command Team consisting of James Miller, Graham Ratcliff, Peter Guelzow and Stacey Mills. He also lauded Paul Willmont for archiving the data. Tynan added Karl Meinzer to the list for his exceptionally hard work on the recovery of AO-40. Clark also mentioned those in the Washington, DC area who have been collecting, and making available, spectral data using the 40-foot dish at the Naval Academy. They include Bob Bruninga, Rick Handley and Ron Parise. Noteworthy also are the contributions of the editor of the DL Web page, who has served as the interface between the project team in Germany and the rest of the world. Baines added Ken Ernandes for his help in tracking AO-40 and Clark added thanks to those who have made it possible for the users to do so much with the telemetry, especially Stacey Mill's AO-40 software package, IZ8BLY, for his demodulator program, and Phil Karn for developing a virtual port Internet connection so that one piece of software can feed another to splice between them via an Internet or direct connection. Jim White was thanked for assisting Stacey Mills with his contributions.

Baker then thanked Barbara Saragovitz, sister of AMSAT Corporate Secretary Martha Saragovitz for her excellent assistance with the Strategic Planning Committee meeting held the previous weekend and Martha Saragovitz for hosting it and her other contributions there. Perry Klein was also thanked for his assistance at that meeting. Baines thanked Chas Richards for putting the Area Coordinator list on the Web site and added that with the help of Russ Tillman there will soon be an Area Coordinator's Toolkit available on a CD ROM.

Tynan thanked those who presented material at this meeting including Lyle Johnson, Bdale Garbee, Phil Karn, Lou McFadin, Stan Wood, Jan King, Dick Jansson and Harwood Shepard and all who participated. He also acknowledged with thanks the help of Bill Hook, W3QBC who transcribes the tapes made at these Board meetings.

XIV. Adjournment

The meeting was adjourned by the Chairman at 1550 EST on 25 February 2001. He announced that the Board will reconvene by teleconference to consider matters that may come up.■



19th Space Symposium & AMSAT®-NA Annual Meeting October 5, 6 & 7, 2001

IARU Satellite Meeting October 7, 2001

Hotel:
Holiday Inn Select, 130 Clairemont Ave., Decatur, GA 30030. Phone: (800) 225-6079 or +1 (404) 371-0204 Fax: +1 (404) 377-2726. AMSAT Group Rates: $79 + taxes (Standard room for 1 or 2 people/night). Parking is $5 per day for hotel guests. **http://www.basshotels.com/holiday-inn? franchisee=ATLDC**

Transportation:
Transportation to/from Hartsfield International Airport to The Holiday Inn Select: Use MARTA rapid rail transport from the Airport - $1.75 each way. Take Hartsfield Airport (Station S7) to the Hotel (Station E6) http://www.itsmarta.com/riding/railmap.htm Taxi and shuttle service is available outside the baggage claim area.

Airlines:
To make reservations and utilize AMSAT contracted reduced fare call: Delta Airlines Meeting and Sales Div. Reservations at: (800) 241-6760. Reference Contract #179729A, which provides a discount of 10% off the lowest published Delta fare 60 days prior to travel; 5% if less than 60 days in advance. Good for travel between October 2nd and October 11th, 2001.

A Sunday morning field trip to The Weather Channel is scheduled, pending local confirmation

Description	Cost	How Many	Amount
Registration (Includes Conference Proceedings)			
Until September 15, 2001	$25.00		
After September 15, 2001	$30.00		
At the Door	$35.00		
Saturday Night Banquet	$30.00		
Sunday Morning Field Trip Bus	$10.00		
Make checks payable to AMSAT-NA in $US		**TOTAL**	**$**
Or: Visa/MC (only)			**Exp. Date**
Daytime Telephone	**Signature**		

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